Boulder Creek Restoration Project

Fire and Fuels Report

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Introduction

Fire management includes all of the activities undertaken for the purposes of firefighter safety, public safety and community protection. Fire management also includes the protection of resources and other values at risk from wildfire, and the use of planned and unplanned ignitions to meet land and resource management goals and objectives. Forest Service fire management activities always put human life as the single, overriding priority.

This report describes the Boulder Creek Restoration Project (BCRP) area as it relates to fire management. In particular it summarizes the forest types, as well as the fire regimes and fire history and how they, together with past management, have contributed to the current condition of the fuels in the analysis area and the potential fire behavior associated with them. This report describes the desired conditions related to fuels and fire behavior and the environmental consequences for each of the alternatives (No-Action, Preferred Alternative, and Alternative 3) and to what degree each meet the specific project goals and objectives related to fire management, which are:

1. Maintain and improve forest landscape resiliency by providing for tree species, stocking levels, and landscape patterns that better resist stand-replacing wildfire(s).

2. Protect the communication site infrastructure and Black Mountain tower from potential wildfire damage.

3. Return the role of fire to the ecosystem.

Proposed activities were designed to achieve these aforementioned project goals. Specific actions which would have a direct or indirect effect on fuel characteristics and expected fire behavior include: commercial timber harvest, pre-commercial thinning, prescribed fire (pile burning, underburning, and natural fuels burning), and a proposed fuel-break. Road storage and maintenance could have an indirect effect on the management of future fire, so it will be discussed as well. Other proposed actions, such as noxious weed control, aquatic organism passages, beaver restoration in Boulder Meadows, and improvements to recreational opportunities have either minimal or no anticipated effects on fire behavior and fuels (especially at the landscape scale), so they are not discussed in this report.

Relevant Laws, Regulations, and Policy

Regulatory Framework

Land and Resource Management Plan

The Idaho Panhandle National Forests Land Management Plan (forest plan) provides forest-wide, as well as management and geographic area guidelines, objectives and desired conditions for the fire resource.

First and foremost, the forest plan identifies public and firefighter safety as the top priority for all fire management activities. Forest-wide direction includes reducing fuels within the wildland urban interface (WUI) and where other values are at risk. Desired fire behavior and fuels conditions exist which allow for safe and effective fire management and low-intensity surface fire is preferred with limited crown fire potential. Forest conditions and patterns are such that there is low risk for stand-replacing fire. Additionally, it is desired that the use of wildland fire (both planned and unplanned ignitions) increases in many areas, helping to trend vegetation toward desired conditions while serving other important ecosystem functions.

Forest plan objectives related to fire include the treatment of fuels on approximately 6,000 to 16,000 acres annually, placing the greatest priority on NFS lands within the WUI. Lastly, over the life of the plan, the objective is to manage 10% of natural, unplanned ignitions (i.e. fires ignited by lightning strikes) to meet resource objectives.

Management Area

The Forest Plan identifies four management area designations for National Forest System lands in the BCRP area (MA 2b – Eligible Wild and Scenic River, MA 4a – Research Natural Areas, MA 5 – Backcountry, and MA 6 – General Forest). Approximately 57% of the BCRP is in MA 5 and 39% in MA 6; management activities are proposed in both. There are no management activities proposed in the small amount of MA 2b or the Hunt Girl RNA (MA 4a).

In the Backcountry (MA 5), the desired condition and guideline is that fire (planned and unplanned ignitions) be used to meet resource objectives, in fact, fire serves as the *primary tool* for trending the vegetation toward desired conditions, while serving other important ecosystem functions (such as providing for wildlife habitat improvements).

Across the General Forest (MA 6), the plan guides for reduced fuels, particularly within the WUI to reduce the threat of wildland fire. Approximately 8,700 acres of the BCRP area occurs within the WUI and values have been identified that warrant protection. The communication site and lookout tower on Black Mountain, and the route into and out of that site, are considered critical points of protection from fire damage. In addition, small community water systems (i.e. Paradise Valley) occur just north of the BCRP; addressing fuel hazards in the Boulder area could have a beneficial impact on the WUI values adjacent to the Boulder project area as well. Reduced expected fire intensities from managed fuels also helps provide for the safety of fire fighters in the event that a wildfire needs to be suppressed. Planned and unplanned ignitions to meet resource objectives can be utilized in this management area as well. At the landscape level, forest conditions exist such that there is a low risk of stand replacement wildfires.

Federal Law

The Federal Land Assistance, Management and Enhancement Act of 2009

The Federal Land Assistance, Management and Enhancement Act of 2009 (the FLAME Act) was signed by President Obama in November 2009. The Act states, in part, “Not later than one year after the date of the enactment, the Secretary of the Interior and Secretary of Agriculture shall submit to Congress a report that contains a cohesive strategy be developed addressing seven specific topic areas ranging from how best to allocate fire budget at the Federal level to assess risks to communities, and prioritize hazardous fuels project funds. The FLAME Act is the catalyst for bringing fire leadership at all levels together and prompting a new approach to how wildland fire is managed. This new approach will guide the development of a national cohesive strategy that paves the way for developing a national wildland fire management policy.

Clean Air Act

The Clean Air Act (Section 110) requires states to develop State Implementation Plans (SIPS) which identifies how the State will attain and maintain national air quality standards. Three elements of the Clean Air Act generally apply to management activities that produce emissions (1) protection of ambient air quality standards, (2) conformity with state implementation plans, and (3) protection of visibility in class 1 airsheds. The Clean Air Act of 1977 (as revised 1991), requires the Environmental Protection Agency (EPA) to identify pollutants that have adverse effects on public health and welfare and to establish air quality standards for each pollutant. Each state is also required to develop an implementation plan to maintain air quality.

State and Local Law

To comply with the Clean Air Act, approval to burn will be requested through the Montana/Idaho Airshed Management System (Airshed Group) in compliance with the Idaho State Implementation Plan. If necessary, the Idaho Department of Environmental Quality issues burn closures in order to protect air quality. The IPNF complies with all recommendations of the Airshed Group to limit smoke accumulations from project activities, to legal, acceptable limits.

Other Guidance or Recommendations

Federal Fire Policy

Federal fire policy is outlined in the *Guidance for Implementation of Federal Wildland Fire Management Policy* (February 2009). This document provides revised direction for consistent implementation of the *Review and Update of the 1995 Federal Wildland Fire Management Policy* (January 2001). The guidance affords that the full range of strategic and tactical options be available and considered in every response to wildland fire. These options are to be used, specifically, to achieve objectives in Land and Resource Management Plans for all wildland fire – both wildfires and prescribed fires. The guidance also calls for increased dialogue and collaboration between all agencies – federal, state, local, and tribal. The BCRP purpose and need and proposed activities were developed through the collaborative process of the Kootenai Valley Resource Initiative (KVRI) – a community-based, collaborative effort in the Kootenai River Basin whose mission it is ‘to improve coordination of local, state, federal and Tribal programs to restore and maintain social, cultural, economic, and natural resources’ (www.kootenai.org/kvri).

Guiding principles of the policy include: firefighter and public safety as the first priority, the role of fire as an essential ecological process, accomplishing activities in support of forest plans, ensuring fire management programs are economic and are based upon protecting values, costs and forest plan objectives, and that activities are founded upon the best available science. Any fire use would be accomplished in accordance with the guidance, with the overall intent to meet forest plan objectives of protecting values at risk of fire.

Forest Service Manual

The authority for fire management on NFS lands is described in Forest Service Manual (FSM) 5100- Fire Management. FSM 5105 describes fuel as combustible wildland vegetative materials, living or dead. Objectives of *fire* management (FSM 5140) include (among other things): altering fuel profiles so that public and firefighter safety is improved, values-at-risk are less vulnerable to impacts from wildfire, as well as achieving desired conditions and management objectives in forest plans. The objective of *fuel* management (FSM 5150.2) is to identify, develop, and maintain fuel profiles that contribute to the most cost-efficient fire protection and use program in support of forest plan direction.

Community Wildfire Protection Plan (CWPP)

The Boundary County Wildland/Urban Interface Fire Mitigation Plan (CWPP) was developed in 2003 (Amendment 1 defining the county WUI in 2004, with annual updates) through a cooperative process and integrates the National Fire Plan, the Healthy Forests Restoration Act and the requirements of FEMA for a wildfire plan. Goals are numerous and include reducing the potential of wildfires that threaten people, structures, infrastructure, and *the unique ecosystems* of Boundary County, Idaho.

Topics and Issues Addressed in This Analysis

Purpose and Need

There are 3 key objectives related to the fire and fuels resource driving the need for the Boulder Creek Restoration Project: the need for increased resistance to stand-replacing wildfire, the need for fuels reduction around the Black Mountain communication site to protect it from wildfire damage (and provide for firefighter safety), and the need to return the role of fire to the Boulder Creek ecosystems.

Issues

The issues relevant to the fire resource specific to the Boulder project area are:

- Forest fuels conditions in all layers (surface, ladder, and crown fuels), which could contribute to severe surface fire or crown fire behavior (fires which can be stand-replacing). This is of particular concern in the WUI and where other values are at risk (i.e. old growth values).

- Utilization of planned ignitions to disrupt fuel continuity, trend towards desired vegetation conditions, and increase options for the management of future fires.

Other Resource Concerns

Air quality is an important resource to consider; however, there are generally few issues or concerns in regards to air quality from project activities because the Forest complies with all laws, regulations and policies regarding smoke management. The forest always cooperates with the regulating agency's recommendations for when and how much burning occurs at any one time so that standards are met. Resource indicators and measures related to air quality were not selected for analysis because the proven protocols already in place minimize project impacts. See the project file for more information.

The management of the road system could have an indirect effect on future fire management options, specifically in regards to fire suppression response, strategies, and tactics. Therefore, road maintenance, storage, and other road management activities will be discussed in the effects by alternative.

Resource Indicators and Measures

Indicators were selected to measure factors contributing to fire behavior for the existing condition and both action alternatives. The fire indicators help summarize how well each alternative responds to those issues driving fire and fuels management and policy, as well as how well each meets the purpose and needs of the project related to the fire and fuels resource. These include helping to create landscape resilience by providing for stands resistant to stand-replacing fires (both severe surface fire and crown fire can be stand-replacing), reducing fuels in the WUI and protecting communication infrastructure on Black Mountain, and returning the role of fire to the Boulder project area. These indicators are summarized in the table below.

Table 1 – Resource indicators and measures for assessing effects

Resource Element	Resource Indicator	Measure	Used to address: P/N, or key issue?	Source
Surface Fuels	Fuel Models & Fuel Loads	Flame Lengths (Feet)	Yes	Forest Plan Desired Condition – FW-DC-FIRE-02
Ladder Fuels	Canopy Base Heights (Feet)	Probability of Torching (%)	Yes	Forest Plan Desired Condition – FW-DC-FIRE-02
Canopy Fuels	Canopy Bulk Density (kg/m3)	Crowning Index (Winds in mph)	Yes	Forest Plan Desired Condition – FW-DC-FIRE-02

In addition to the above resource indicators/measures, the use of fire across the landscape to trend toward desired resource conditions, disrupt fuel continuity, help maintain dry-site old growth, and create a mosaic of stand structures will be discussed and evaluated by acres treated by alternative. The use of fire through planned ignitions would be used to meet the purpose and need. Utilizing planned ignitions to meet resource objectives is a forest plan desired condition, specifically in MA5 – backcountry.

Flame lengths were used to determine surface versus crown fire potential and the trends of flame lengths as a measure of treatment effectiveness on the surface fuels over time. This is particularly important where suppression is likely in the event of a wildfire; suppression tactics are directly related to flame lengths (flame lengths less than 4 feet are desired because they can be attacked using hand crews to construct fire line). Flame lengths greater than 4 feet require other resources such as dozers or aircraft carrying water or retardant (NFES 2165, NWCG 2006 p. B-59); though all methods of *direct* attack are ineffective when flame lengths exceed 8 feet. As crown fire behavior would exhibit flame lengths far in excess of this threshold, the analysis of the alternatives summarize total expected flame length in addition to surface flame lengths. The type, arrangement, and loading of surface fuels directly influence the expected flame lengths in a forested stand, so fuel loading (as summarized by fuel model) are presented in the existing condition and analysis as well.

A torching situation is generally defined as one where tree crowns of larger trees are ignited by surface fire flames or flames from smaller burning trees reaching the larger trees. Torching can lead to crown fire behavior and crown fires are almost always stand-replacing; thus a low potential for torching is desired. Torching is sensitive to surface flame length, understory development and ladder fuels, and crown structure. Low canopy base heights and foliar moisture are critical for torching potential (Agee and Skinner 2005); therefore, canopy base heights beyond the level where surface fire can transition into the tree crowns is desired. Management actions that reduce surface flame lengths and remove ladder fuels, reduce the **probability of torching** within a forested stand.

Crown fires are by general rule very destructive to forest resources as they move quickly and most means of firefighting are ineffective at controlling them (Scott and Reinhardt 2001). The **crowning index (CI)** is the windspeed 20 feet above the canopy at which active crowning is possible and it reflects density of the crown fuels. Active crown fire is one in which the entire surface/canopy fuel structure is involved. Passive crown fire is the torching of individual or groups of trees. Fuel structures which support crown fire – ladder fuels and a high canopy fuel load would result in a low CI (low winds could sustain a crown fire), while fuel structures such as minimal surface and ladder fuels and spaced tree crowns would result in a high CI (very high winds would be necessary to support crown fire); which is desired.

Methodology

The existing condition and environmental consequences of the alternatives associated with the BCRP as related to fire and fuels were determined using archived fire history data, past activity data, aerial photography, GIS data layers, stand exams, site-specific assessments for fuels conditions, as well as fire behavior modeling programs. Data was assessed specific to the analysis area defined below and utilized in conjunction with research to provide context for the environmental effects of the alternatives.

Information Sources

LANDFIRE

LANDFIRE (Landscape Fire and Resource Management Planning Tools), is a shared program between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior, providing landscape scale geo-spatial products to support cross-boundary planning, management, and operations. LANDFIRE provides an all land data set of vegetation and wildland fire/fuels information. The fuel data layers can be used for applications at varying scales, including project level planning. LANDFIRE data may be used for modeling potential fire behavior and effects to strategically plan projects for hazardous fuel reduction and the restoration of ecosystem integrity on fire-adapted landscapes (http://www.landfire.gov/landfire_fact_sheet.html). For field verifying LANDFIRE data, users should focus on the efficacy of the data rather than on the accuracy. In other words, it is more helpful to understand how well the data meet their stated objectives, which are to 1) help answer questions related to strategic fuel management and 2) support wildland fire incident response."

The result of the field verification is that the LANDFIRE data is not perfect, but is generally accurate, especially when considered on a relative scale. However, LANDFIRE tended to underestimate the canopy base heights (CBH) of many sites within the resource area evaluated. Other than this one metric, which can easily be measured through on-site observation, LANDFIRE data is highly useful because it is complete in both fuel attributes and spatial extent – especially for Fuel Model and Canopy Bulk Density. It is particularly useful for project-level analysis; for this project it was specifically used for fuel model occurrence across the landscape.

Field Data

Field data for the analysis of the fire/fuels resources was collected to determine existing fuels characteristics, as well as to verify accuracy of fuel data layers as described above, and to provide inputs as needed for fire behavior modeling. Site visits for fuels conditions were done on several occasions beginning in the late summer of 2013 through summer 2016. Data collected included photo points, fuel model determination, ladder fuels and canopy base heights, estimates of canopy fuels, forest type and species compositions, and summary of surface fuel loadings in tons/acre (small and large woody fuels, brush, grasses, etc.). Additional information gathered included slope, aspect and other topographic features contributing to potential fire behavior, spread, and intensity. All field notes are available for review in the project file.

Fire Behavior Modeling

Several computer-based models are available for predicting surface fire behavior, as well as the potential for crown fire. These different programs generally incorporate the same underlying surface fire behavior model which was described in *A mathematical model for predicting fire spread in wildland fuels* (Rothermel 1972). Use of these models can help managers identify areas of hazardous fuels and associated high fire behavior and set priorities for management or suppression tactics during a wildfire.

For this analysis, the models were used specifically to compare the potential fire behavior of the existing condition with that of the proposed activities and to help analyze how fuels would be reduced, or vegetation affected by the use of fire on the landscape. As with all models, capabilities vary and assumptions and limitations exist, but knowledge of fuels, weather, and other site specific conditions, as well as accuracy of model input data can provide for useful and reliable fire behavior predictions. For more information on these models, see the project file for a description of models used, including the capabilities, assumptions and limitations.

Fire and Fuels Extension to the Forest Vegetation Simulator

The Forest Vegetation Simulator (FVS) is used by forest managers to model the effects of various vegetation management actions on forest conditions. It uses stand exam data to predict forest growth and decline over time. The Fire and Fuels Extension (FFE) of FVS incorporates existing fire behavior models and was used in this analysis to describe effects on stand-level fuels conditions and fire behavior ***into the future***. It was used to compare expected fire behavior in a treated vs. untreated stand and to provide estimates of how long management actions associated with the alternatives (regeneration harvest followed by burning) may be effective at reducing fuels to modify fire behavior, for each indicator measured. Current fuels characteristics provided in the main output file of FVS (species composition, stand densities, canopy base heights, canopy bulk density, and other fuel characteristics) were compared to on-the-ground observations to ensure the model usefulness in this analysis.

NEXUS v2.0

Nexus is a crown fire hazard analysis program. It is able to link separate models of surface and crown fire behavior to compute indices of relative crown fire potential. It is set up to directly compare stands. Nexus was used to compare treated and untreated stands and expected crown fire potential. See the project file for more information.

Spatial and Temporal Context for Effects Analysis

The fire behavior indicators were used to summarize direct effects at the stand-level or treatment unit as data related to forest vegetation and fuels is often inventoried and summarized at this scale. In addition, the FVS-FFE model characterizes and models vegetation and fuel characteristics this way. Specific modifications to the fuels and fire behavior which would occur from implementation of an action alternative (i.e. changes in fuel loading and how those changes affect factors such as flame length) are summarized immediately following implementation, as well as into the future several decades. This provides context for how long individual treatments have an impact on the fire and fuels resource and allows effects to be summarized in both the short- and long-term by alternative.

However, this project takes a landscape approach to restoration, crossing a variety of forest types, structures, compositions, disturbance regimes, and land uses and management legacies. Beyond the treatment unit or stand, research provides context for the indirect and cumulative effects of treatments, so those effects are described at a landscape scale. The analysis area for describing these effects, as well as the existing condition, is the Boulder Creek Restoration Project area (approximately 40,500 acres in size). It is made up of the entire watershed for Boulder Creek, including the sub drainages which feed into it. It includes a portion of the county defined WUI (approximately 8,700 acres of the analysis area, or 21%).

Figure 1 displays the spatial extent for indirect and cumulative effects. It extends to where topographical features and influences create reasonable barriers to fire movement and reflects areas of historic fire occurrence and spread throughout the drainage. Factors such as aspect, slope, and terrain influences on weather and wind patterns, forest types, fuel continuity, and natural fuels breaks are addressed because they all have an effect on fire. In regards to fire management, it defines a logical extent for assessing whether or not to utilize fire for resource objectives or develop suppression strategies in the event of a wildfire. The cumulative effects analysis considers management, fire history and a legacy of fire suppression back as far as records have been kept (early 1900s), as it is assumed all these factors have contributed to the current condition of fuels and anticipated fire behavior in the analysis area.

For the purposes of this report, short-term effects are those within approximately 5-7 years of project implementation, coinciding with about how long it is expected to take small woody fuels to naturally mitigate in some of the proposed treatment areas. When referring to long-term effects in this report, it is for a period of time beyond that.

Affected Environment

Existing Condition

Weather and Topography

In the event of a wildfire, general wind direction from southwest to northeast may aid in large fire development in that direction. At a more localized scale, diurnal winds are upvalley and upslope, moving fire in the direction of the steep terrain. This could place an area like Black Mountain at risk in the event of a fire start downslope of it. Strong summer winds are generally associated with cold fronts, which can have an effect on fire behavior due to shifts in wind direction and downdrafts.

Slopes in the proposed treatment area range from nearly flat (0-10%) to very steep (>70%); slope is a large contributor to fire behavior and spread. In general, a fire burning upslope aided by the wind will have the greatest spread rates and be difficult to control (Weise and Biging 1997). Due to slope, radiant and convective energy transfer provides sufficient heating of the fuel ahead of the fire front to produce a flame front supporting more rapid upslope fire spread (Rothermel 1972) (Weise and Biging 1996 and 1997), especially a concern where slopes are very steep. Fuel moistures are generally drier on south and west aspects, as compared to north and east aspects, due to direct sun exposure during the hottest parts of the day. Most of the proposed treatment areas north of Boulder Creek and the main Twentymile road have a generally southerly exposure and during fire season, both live and dead fuel moistures would be low, relative to north or east aspects, making nearly all fuels available to burn.

Fire History

Fire is the major disturbance factor that produces vegetation changes in our ecosystems (Spurr and Barnes 1980). Every forest type occurring in northern Idaho has experienced fire; vegetative structure, function, and processes rely on it. Fire was responsible for the widespread occurrence and even existence of western larch, lodgepole pine, and western white pine and maintained ponderosa pine on sites throughout its range at lower elevations and killed ever invading more shade-tolerant species on those sites (Spurr and Barnes 1980). Thus, it stands to reason if the role of fire is altered or removed (i.e. fire suppression), it will produce substantial changes in the ecosystem.

Fire can have variable effects as it moves across the landscape and is influenced by daily, weekly and monthly changes in weather (Arno et. al 2000). Each forest formed under a fire regime, as is evident from just a portion of the local fire history, characterized in part by the ‘type’ of fire severity affecting the dominant vegetation and how often fire occurred. There are 3 levels of fire severity (Zack and Morgan 1994; Arno et al. 2000):

- **Stand-replacing (Lethal or high-severity)** – fires that kill all or most of the overstory trees and initiate forest succession across a large and generally uniform area. These are commonly crown fires that burn with high severity.

  Fire return interval is generally infrequent. Local examples of these types of fires are the Sundance and Trapper Peak fires in north Idaho in 1967 that together burned over 80,000 acres in a short time period during drought conditions.

- **Non-lethal fires (low-severity)** – fires where most of the dominant tree canopy survives. A much larger percentage of small understory trees, shrubs, and forbs may be burned back to the ground line.

  Fire return interval is generally frequent.

- **Mixed-severity fires –** fires that commonly burn with 'variable' severity across the landscape, producing irregular, patch mosaics; many trees die and many trees survive.

  Fire regimes are considered variable – there may be short return intervals of non-lethal fires with infrequent interval lethal crown fires.

In the BCRP, historic **low-severity, or non-lethal, fire regimes** would have helped contribute to the development of the drier ponderosa pine and Douglas-fir forests. These primarily occur on lower-elevation south aspects north of the main Boulder Creek, from Clifty Creek to the east of Gable Creek (also near North Creek as well). Multiple fire scars are prevalent on large old trees in these areas, suggesting at least some frequent, low-intensity fire in which many trees survived. Local fire history analysis suggests fire historically occurred every 40 or so years on these drier sites (with a high amount of variability on both sides of this average). More frequent fire may have resulted in greater compositions of fire-tolerant species (western larch and ponderosa pine) and structures consisting of large older trees with openings – where the fires killed off the smaller and younger susceptible trees without causing mortality in most of the overstory. However, there is much research to suggest that at a *landscape level*, these forests were historically more consistent with mixed-severity fire regime; some areas of openings with large old-trees adjacent to dense areas developing from high-severity fire (Baker et al, 2006). The natural patterns of dry forest compositions and structures favored these types of fire by maintaining a semi-predictable mosaic, isolating the conditions which would support high-severity fire (Hessburg et al. 2005).

Mixed-severity fire regimes also occurred at mid elevations, where a moisture gradient results in a mosaic of tree species referred to as mixed conifer forest (Schoennagel et al. 2004) – ponderosa pine, Douglas-fir, grand fir, western larch and lodgepole pine are all common. Low severity fires did occur in this regime and research suggests shade-tolerant species, such as grand fir, have increased in response to the suppression of these lower-severity fires. Fire suppression has likely removed the low severity burns that occurred between stand replacing events. Therefore, forest structures may be more homogenized across the landscape resulting in the potential for larger patches of crown fire than were witnessed historically (Schoennagel et al. 2004).

There are other ecologic considerations for these sites in regards to fire. In particular is the effect of white pine blister rust on species compositions. The introduction of this disease resulted in a large decrease in western white pine in the mixed conifer forest types. Uncharacteristic insect and disease can alter structure and composition, and therefore the occurrence and effects of disturbance (such as fire), as compared to what may have happened historically (see the Vegetation Report).

The forest types that occur in the higher elevation subalpine stands in the BCRP are composed of high density lodgepole and subalpine fir, all thin barked trees easily killed by fire. **Stand-replacing fires** occurred historically at long intervals – on the moister sites successive seasons of drought can initiate large stand-replacing fires and these fire events generally account for large areas burned (Shoennagel et al 2004). Historically, these fire regimes often experienced long fire free intervals beyond the current period of fire exclusion and research suggests it is unlikely fire suppression activities have 'significantly altered the long fire intervals in subalpine forests' (Shoennagel et al. 2004). Long fire free intervals do allow for the accumulation of fuels contributing to the typical high-severity fires when they do occur.

The term 'significantly' is important here because most of the more recent fire starts have resulted in very little acres burned as they were suppressed as small spots generally less than 1 acre. Had they not been suppressed, these fires *could* have burned for 1-2 months or more during the fire season, growing unchecked and burning hundreds or even thousands of acres, until fall rains put them out. One conclusion is that although fire suppression may not have interrupted the range of stand replacing events (50-200 or more years), the mixed and non-lethal fires which occur between stand-replacing events (every 30-50 years on average) have been missing with fire suppression (Smith and Fischer 1997).

After the last large fires, many of the mid- to higher elevations (above 3,400 feet) regenerated with lodgepole pine. Increased soil temperatures after stand-replacing fire enhance the germination of lodgepole pine (Smith and Fischer 1997) which is abundant in much of western North America [and in the BCRP area] largely as a result of repeated fires (Lotan et. al 1985). These forests are typified by a structure which carries fire into the canopy in order to promote the intense fire behavior associated with them (Schoennagel et al. 2004) and if the fire history in the BCRP area can tell us anything it is that large scale stand-replacing fires occurred and will likely occur again.

The fire atlas shows a large landscape fire occurred in 1910 within (and beyond) the fire analysis area of this project; field observations suggest the fire was largely stand-replacing but likely included patches of mixed- and even low-severity fire (particularly on drier south aspects where large ponderosa pine dominated historically and still exist today) and may have covered an even greater area than the atlas depicts (see Fire History Map; Figure 1). Other fires occurred on a smaller scale in 1889 and into the 1920s (Figure 1). However, it is believed (based on site-specific fire history data), both the 1889 and 1910 fires burned more acreage in the Leonia Knob and Gable and McGinty Creek areas than the fire history map shows. One assumption is that the fires may have burned with lower-severity in these areas, retaining much of the overstory. Determining the extent of low-severity fire may have been more labor intensive, requiring personnel on the ground, whereas stand-replacing fire could have been easily determined through analysis of aerial photography.

Lightning-caused fires in northern Idaho occur most frequently at elevations from 3,450 to 5,400 feet, a range that includes most of the NFS lands in the resource area. Fire records including the ignition location, size, and cause (i.e. human, lightning) have been kept since the early 1940s on the district, however, the region has been maintaining this information since 1970 and it is believed this 47 year period likely has the most complete and accurate information. Since 1970 there have been 49 fire starts within the Boulder project area, with another 4 ignitions occurring on the border of the project area and 9 starting within a half-mile. Had these fires not been successfully suppressed, each would have had the potential to burn large acreages. Due to suppression, natural fire has been mostly absent from the landscape for 107 years.

Year	Acreage Burned in the BCRP Area
1889	700

1910	27,000
1918	20
1920	20
1926	100
2001	60

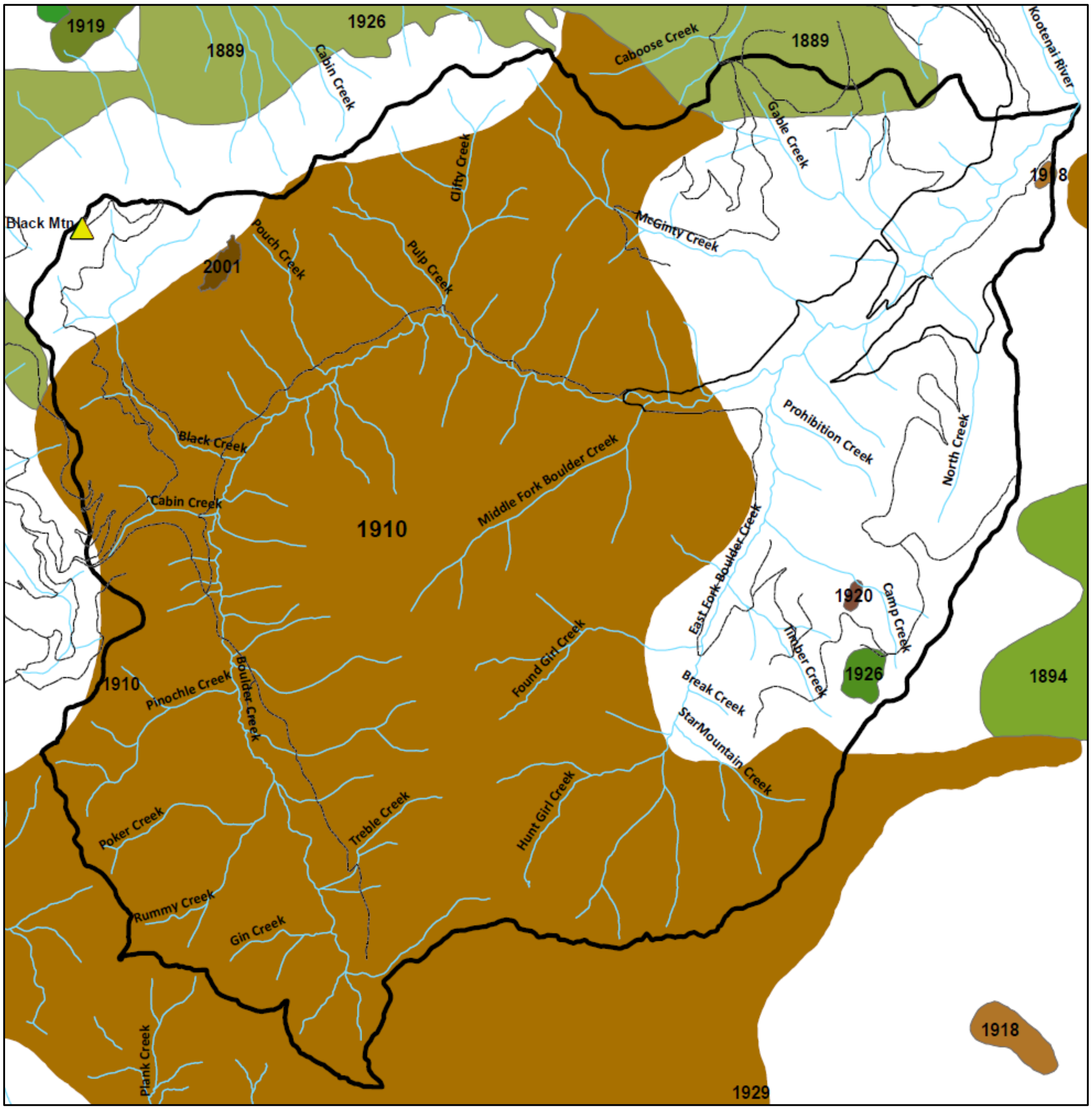


Figure 1 – Known large fire history in the Boulder analysis area (outlined in black)

There is research to suggest that changes in disturbance processes, such as natural fire, has led to large fire regime shifts in Inland Northwest forests. According to Hessburg and others (2005), low-severity regimes have experienced a net reduction of more than 50% and the area of high-severity has about doubled. Even though mixed-severity regimes have stayed relatively similar, much of the area has moved from characteristic mixed-severity to uncharacteristic.

Fuels Conditions and Fire Behavior

Along with natural disturbance factors, such as fire and insects and disease, existing conditions were likely formulated by management influences affecting succession, railroad activity, as well as mining activities, grazing, and fire suppression. These natural and unnatural interruptions to forest development and patterns may have all contributed to the current condition of surface, ladder, and canopy fuels conditions we see in the BCRP area today.

Table 2 – Resource indicators and measures for the existing condition

Resource Element	Resource Indicator	Measure	Existing Condition*
Surface Fuels	Fuel Models & Fuel Loads	Flame Lengths (Feet)	4-8 feet
Ladder Fuels	Canopy Base Heights (Feet)	Probability of Torching (%)	>90%
Canopy Fuels	Canopy Bulk Density (kg/m3)	Crowning Index (Winds in mph)	<15 mph

*These conditions are averages for previously *untreated* stands, see discussion to follow in regards to current fuels conditions in areas which have been previously treated.

Surface Fuels and Flame Lengths

Surface fuels are generally classified into four groups: grasses, brush, timber and slash. The differences in fire behavior among these groups are basically related to the fuel loading and distribution of the fuels making up the fuel particle size classes. For fire behavior predictions, these four fuel groups are further delineated into fuel models which quantify fuel characteristics and properties for determining fire potential (40 dynamic fuel models developed by Scott and Burgan, 2005).

Fire behavior fuel models are used in fire behavior prediction modeling for their physical description of the fuel loading, fuel bed depth, and fuel moisture at which fire will not spread to estimate potential fire behavior. From on-site observations it was determined that the large majority of the mature forest stands on National Forest System lands in the resource area are best modeled by 1 of 3 fuel models (Scott and Burgan 2005):

- Timber Understory (TU) 5: Heavy down woody material (timber litter) and high load conifer litter and shrubs are responsible for fire spread. These fuel conditions often result in intense fire behavior leading to control problems.
  Approximately 50% of the BCRP analysis area.
- Grass-Shrub (GS) 2: This fuel model has a mixture of grass and shrubs (up to 50% shrub cover) that contribute to the surface spread of a fire. Specific to GS2, shrubs are 1-3 feet high, and the grass load is moderate. Fires burning in these fuels can spread rapidly and with a shrub component near the upper level, flame lengths would likely be outside the limit of direct attack. **Approximately 20% of the BCRP analysis area**.
- Timber Litter (TL) 3: This fuel model consist of lighter timber litter, with little other fuels to carry a surface fire, the fuels are best characterized as a TL3 (moderate load of conifer litter). Fires burning in these fuels spread slowly and the expected flame lengths are within desired conditions (1-4 feet). **Approximately 10% of the BCRP analysis area**.

The remainder of the analysis area consists of areas of rock, water, or small patches of scattered fuel types that do not fit into one of the above mentioned categories. Grass dominated areas with little shrubs would fall within a GR (grass) fuel model, while some of the ponderosa pine dominated old growth stands are best represented by a TL8 fuel model where pine needles would be the primary carrier of a surface fire. These other areas account for an estimated 10-15% of the BCRP analysis area, and though they may influence fire behavior at the stand-level, have less influence on large fire development with their current distribution.

Observations of past fire behavior shows that small timber litter and other woody material, less than 3 inches in diameter, have the most substantial influence on fire behavior (such as spread rates and fire intensity) (Brown et al 2003). These small woody fuels are the greatest in the north Idaho conifer stands classified as a TU5 (often exceeding 10 tons/acre in areas see Figure 2 below – desired conditions are around half that). However, it is the large woody fuels (the timber litter also referred to as coarse woody debris, CWD) which contribute to large fire development and high fire severity. The greater the fuel loading of this large material (>3 inches), the greater the influence on fire severity (effects to soil, water, other forest resources) – this is generally due to smoldering and persistent burn periods (Brown et al 2003).

Coarse Woody Debris Recommendations

Lower subalpine	**11-23 tons/acre**
Moist	**17-33 tons/acre**
Moderately dry	**7-13 tons/acre**

Coarse-woody debris is also an important component of a healthy ecosystem. Animal life processes, site productivity and protection, *and* fire are important components of coarse-woody debris most commonly discussed by forest managers (Brown et al 2003). Although the amount of CWD varies throughout the analysis area, the TU5 stands often have jackpots of this heavy down material above the recommended ranges by habitat type (Graham et al. 1994). This is especially true of the lower subalpine stands in the vicinity of the communication infrastructure on Black Mountain – for example, >50 tons/acre were found in Unit 241.

Recommendations for CWD are for desirable biological benefits; balancing this with a low fire hazard is important within the WUI and where other values are at risk. Severity to forest resources can be a concern where CWD is high due to increased flame lengths and prolonged smoldering of the larger fuels – severe surface fire can result in tree mortality and damage to soils due to deep heat transfer (Graham et al. 2004). Crowning out, spotting, and torching are also greater where heavy CWD has built-up in a forested environment (Brown et al 2003). One way to ensure the benefits while minimizing the risk is to manage for large pieces of down woody scattered throughout the treatment area (it takes fewer large diameter pieces to amount to the same tons/acre as it would a lot of small pieces). In particular, disrupting the continuity of jackpots of CWD, or reducing their mass, is important for reduced severe surface fire.

The surface fuels in many of the TU5 stands are such that **surface flame lengths were predicted to be over 5 feet.** Where this overlaps with the WUI, such as in Unit 241, this would especially be a concern for fire managers as this is beyond the limits of safe direct attack by firefighters.

Figure 2 – Example of Fuel Model TU5. These photos are of Units 241 near Black Mountain and Unit 46 (lower subalpine forests) where heavy timber litter and dead and dying trees are contributing to increased surface fuels. There is also a shrub layer and a component of young, regenerating conifers which could behave like a ladder to carry fire into the denser overstory.

Though woody fuels are generally not as heavy in grass and shrub dominated areas, the loading of shrubs would still be a concern. Specific to the BCRP area (example in Figure 3), predicted surface flame lengths were just above 6 feet, also exceeding the 4-foot direct attack threshold.

Figure 3 – Fuels on 'dry' sites. Left: Example of a varied grass and pine needle (TL8) dominated fuel model, grading to a light Fuel Model GS2 in project area (proposed Burn Unit 2). Right: Heavier load Fuel Model GS2. The canopy was opened with commercial thinning approximately 20 years ago. Both typical of warm/dry forest types dominated by ponderosa pine and Douglas-fir.

Some of the mature stands have not yet accumulated heavy timber litter in the surface fuels. These stands are generally homogenous in structure and the overstory is dominated by lodgepole pine of similar size and age (100+ years old, having regenerated after the last stand-replacing fire in 1910). The surface fuels are mostly light timber litter (branchwood, needles, etc. with occasional large pieces of coarse woody debris) with some herbaceous material, low shrubs and light grasses. Many of these occur at upper elevations – along Katka Ridge and near Iron Mountain south along the ridge to Boulder Mountain – others are scattered along the main Twentymile road. In many cases, these stands are intermixed with adjacent areas of heavier down and tall live surface fuels.


Figure 4 – Example of Fuel Model TL3 (Unit 236). The photo on the right illustrates part of the technique in determining small woody fuel load (the woody material <3” in diameter).

Other stands which currently have these lighter woody surface fuels include mature moist mixed conifer stands, with dense overstories and shaded forest floors. Not much is growing in the understory and heavy down fuels have not yet accumulated. Large woody fuel is generally well within the range of recommendations by Graham for these habitat types. These stands have surface fuel characteristics most similar to a TL3 where surface fires are slower burning with low flame lengths (Figure 3). Only under more severe weather conditions do these areas pose a fire hazard (Anderson 1982) *based on the surface fuels alone*.

Even under weather scenarios consistent with high-fire danger**, surface flame lengths in the patches of timber more closely resembling a TL3 would be expected below the 4 foot threshold for direct attack (approximately 2 feet); consisted with the desired condition.** As these stands age they become more flammable, due to events that occur through the life of the stand including overmaturity, understory regeneration of fire intolerant species, insects and disease and other events; resulting in surface fuel conditions becoming more hazardous (Lotan et al 1985).

This is especially true in the homogenous lodgepole pine (which has increased 127 percent – see vegetation report); over time these stands are expected to increase in susceptibility to mountain pine beetle irruptions causing high mortality (Smith and Fischer 1997). Dead and dying trees are expected to accumulate in the surface fuels increasing the likelihood for extreme fire behavior. The majority of these stands already possess the ladder fuels which are important for crown fire initiation.

Ladder Fuels and Probability of Torching

Canopy base height (CBH) is the lowest height above the ground where there is a sufficient amount of canopy fuel to transition a fire from the surface fuels into the tree crowns (Scott and Reinhardt 2001). Therefore, low canopy base heights are a critical factor in determining crown fire potential. For example, if surface flame lengths are predicted to be 4 feet, but the ladder fuels are at or below 4 feet, fire would have an avenue to move up the ladder fuels and into the canopy. Treatments focus on maintaining a condition where ladder fuels (understory trees, tall shrubs, lower branches of large trees) are mitigated, especially where reducing crown fire initiation is a priority into the future (Agee and Skinner 2005).

Canopy base heights are generally quite variable at the finer stand scale. Some areas of a stand may have thick pockets of advanced regeneration eliminating any kind of gap between the surface fuels and the canopies of the overstory trees (see Figure 5 below). In some patches, there may be a large void between the surface fuels and tree crowns Even so, most previously untreated areas have average stand-level canopy base heights of approximately 5 feet (ranging from 0-10 feet). This was true for moist mixed conifer, moderately dry and warm forests, and even higher elevation stands. In these stands the likelihood that torching would occur is above 95%.

At a coarse-scale, the homogeny of the landscape becomes more apparent; lack of disturbance across large portions of the analysis area has resulted in stands of similar age, structures and compositions. Though patches of openings do exist from previous harvest, from a landscape perspective, there is a lot of understory development, and there are many shade tolerant trees which have dense crowns with low-growing branching patterns capable of moving fire up into the canopy.

Figure 5 – Canopy base heights in untreated area. Unit 65 – No recorded past management and no fire since 1910. Note the ladder fuels - continuity from the surface fuels all the way up into the canopies of the overstory trees. CBH <5 feet. This unit is in dry site old growth.

Some harvest with fuels treatments has occurred in the recent past. In many of these areas, the canopy base heights are much higher, averaging >15 feet (See Figure 6). Where the CBH far exceeds the potential surface flame length, the <u>probability of torching is estimated at zero</u>, because the winds necessary to initiate it are unreasonably high (>100 mph). These conditions exist primarily where past harvest left a residual canopy – examples are the dry forest stands near McGinty Ridge (Units 64, 70, and 130, for example).

Figure 6 – CBH in previously treated area. Unit 64 (Left) and Unit 128 (Right) – Commercially thinned in the late 1990s. Note the large space between the base of the tree canopies and the surface fuels. These units have canopy base heights that average >15 feet.

Canopy Fuels and Crowning Index

Canopy bulk density (CBD) is the mass of available fuel per unit of canopy volume (kg/m^3) – the bulk property of a stand, not an individual tree (Scott and Reinhardt 2001). Scott and Reinhardt (2001) describe the criteria necessary for active crown fire: Mass-flow rate is defined by Van Wagner (1977) as the rate of fuel consumption through a vertical plane within the fuel bed and it is a product of CBD and spread rate. CBD affects the critical spread rate needed to sustain active crown fire and thus the lower the CBD, the lower the potential for active crown fire. Typical dense, moist stands with large climax species (specifically cedar, grand fir, and hemlock which have large branches all the way down to the forest floor) can have a very high CBD – some of the greatest CBD are near 0.30 kg/m^3 (Keane et al. 2005).

Canopy bulk densities were estimated from a *Stereo Photo Guide for Estimating Canopy Fuel Characteristics in Conifer Stands (*Scott and Reinhardt 2005) and from outputs from FFE-FVS. In the mature, previously untreated stands, canopy bulk densities range from 0.10-0.25 kg/m^3 and average 0.16 kg/m^3 (a value where crown fire could easily be supported). In these stands crowning index is generally <15 mph – meaning if a torching situation occurs, the fire could be sustained in the canopy with winds around 15 mph which are common in the summer in north Idaho.

Where past harvest has occurred, such as in unit 64, CBD is much lower and within the desired range (<0.05 kg/m3). Even if fire were able to transition to an individual tree crown, the winds necessary to sustain active crown fire is estimated near 50 mph. Winds at this level are not unheard of, but are unusual and generally not sustained, thus the potential for active crown fire in these stands is essentially zero.

Fuels Conditions in Dry-Site Old Growth

The warm/dry forests, dominated by large ponderosa pine and Douglas-fir, currently have a mix of fuel characteristics. These stands have not experienced fire disturbance in over 100 years (possibly longer for units 233 and 235 which were outside the 1910 fire area). In the absence of fire, regeneration since the last fire has been growing for over a century. Though many of these areas are still best represented by a GS2 fuel model at the stand level, they have pockets of heavy fuels like a TU5. These stands have vertical continuity of fuels and dense, mature overstory (refer to canopy base height and canopy bulk density discussion), of which at least at the landscape-scale, may have been less prevalent had fire been allowed to play a natural role over the last century.

Figure 7 – Fuels in the old growth proposed for prescribed fire. Fuels conditions are a mix of grass, small shrubs, timber litter, and regenerating Douglas-fir. Ladder fuels have developed and stand densities increased with the absence of any type of fire.

Environmental Consequences

Effects Common to All Alternatives

Fire Occurrence

Probability of ignition is strongly related to fine fuel moisture, air temperature, shading of surface fuels, and an ignition source (Graham et al. 2004). In a stand that is opened up to the elements (i.e. a stand which has been thinned or regeneration harvested), the chance for a fire start and spread from an ignition source may actually increase due to increased surface temperatures and lower humidity; there is generally a warmer and dryer microclimate in more open stands (Graham et al. 2004) (Agee and Skinner 2005). Untreated stands with a dense overstory will have greater shading of the surface fuels, and higher humidity and live fuel moistures (Graham et al. 2004), affecting ignition potential. However, the chance for ignitions is still present under the canopy when fire danger is high and if left untreated there will be more fuel for a fire to consume and build fire intensity.

Regardless of the actions taken within the Boulder analysis area, wildfires will still occur. Implementation of activities such as harvest or prescribed burning will not affect the likelihood of lightning strikes which are the greatest cause of fire ignitions in the project area. No matter the management implemented, treatments can modify fire behavior but not fire proof forests (Reinhardt et al. 2008).

Alternative 1 – No Action

Direct effects (those which are caused by the action and occur at the same time and place) to the fire and fuel conditions would be absent under the No-Action Alternative because no activities are proposed. As undesired fuels characteristics would be maintained in many areas of the BCRP area, this alternative does not respond to the project purpose and needs associated with the fire resource. Increasing landscape resistance to stand-replacing fires, reducing the threat of fire to communication infrastructure and the tower at Black Mountain, or returning fire to the ecosystem, would not occur under the No Action alternative.

Surface Fuels and Flame Lengths

For the Fuel Model TU5 and GS2 stands, doing nothing maintains the existing condition and further fuels accumulation in the future. Growth and competition will continue until trees die and fall in the absence of disturbance, exacerbating the potential intense fire behavior. High loadings in large woody fuels could contribute to severe fire effects in a future fire through prolonged smoldering and residence time [the duration of time it takes the flaming front to pass through the fuel bed] (Peterson et al. 2015). According to Brown and others (2003), fires generally exhibit high fire behavior ratings and a high resistance to control (difficulty related to constructing and holding a control line as affected by fire behavior) when large woody material exceeds around 30 to 40 tons/acre, of which many of these stands have or would be expected to have in the future. Specific to the dry-forest old growth, severe surface fire could result in mortality to the large old trees, such that these stands no longer meet the definitions of old growth (for dry forest habitat types, a minimum of 8 trees per acre at least 21 inches diameter and at least 150 years old are required to be considered old growth).

Some individual patches of mature timber have not developed the heavy down woody surface fuels. However, many of these stands have a large component of lodgepole pine, which is short-lived relative to many other seral species. Most lodgepole pine dies in subalpine stands of northern Idaho within 120 to 160 years of stand origin (Cooper et al. 1991), more quickly on moist sites than dry sites (Pfister and Daubenmire 1975). As the fire history and inventory data suggests, most of these stands are >100 years old now; in the future as trees begin to die and fall over surface fuels would continue toward a TU5 fuel model. Further, in the absence of fire disturbance or restoration activities, continued stand transition to late-seral species increases ladder fuels and stand susceptibility to torching (Smith and Fischer 1997).

Ladder Fuels and Probability of Torching

Without harvest and fuels treatments or prescribed burning, higher surface flame lengths coupled with low canopy base heights (ranging from about 0-10 feet, averaging 5 feet) maintains a high probability of torching above 95%. This potential for transition to crown fire would be expected to remain into the future, as surface and ladder fuels continue to accumulate (see Figure 11). As forests go through stages of succession, more shade-tolerant trees dominate and these species, such as western redcedar, grand fir, subalpine fir, and western hemlock, all have low-growing crown structures which contribute to low canopy base heights and torching.

Canopy Fuels and Crown Fire Activity

Once torching puts fire in the crowns of the overstory trees, the crown structures and available fuel load (canopy bulk densities from 10-25 kg/m3) remain sufficient, without treatment, that active crowning could continue with 20 foot winds around 15 mph. Wind speeds such as this, and higher, are not uncommon in the summer, especially with the passage of cold fronts.

Crown fire activity represents a problem for fire managers (Rothermel 1983) due to the high rates of spread and very high intensity. Crown fires are a risk to values such as life and property and limit firefighting capabilities and tactics due to firefighter safety. Specific to the BCRP, crown fire activity would especially be a concern near the communication infrastructure and tower on Black Mountain. If a fire were to transition to a crown fire, then flame lengths could be greater than 80 feet and fire spread rates could exceed 70 chains per hour (this equates to approximately 3/4 of a mile spread in an hour). Both values are beyond firefighter abilities to direct attack a fire; direct attack requires flame lengths of less than 4 feet and a rate of spread at less than 5 chains per hour (330 feet in an hour). In addition, spotting and increased radiation make values at risk more difficult to defend than a surface fire (Cohen and Butler 1998 and Scott and Reinhardt 2001). In regards to resistance to stand-replacing fire, crown fires nearly always result in total tree mortality (Scott and Reinhardt 2001).

The areas which were harvested in the recent past exhibit a low likelihood for crown fire activity due to reduced canopy fuels. However, these moderated conditions will not last forever and over time the developing understory will become ladder fuels. In those stand which were commercially thinned, FVS-FFE outputs show that 20 years post-entry canopy base heights are predicted to be below the level of expected surface flame lengths (approximately 4 feet). Canopy fuels were predicted to still be adequately reduced so that active crown fire could not occur. However, under conditions of high fire danger, predicted surface fire intensities and flame lengths with occasional torching could contribute to mortality to the overstory trees.

Under the no action alternative, none of the previous regeneration harvests (now seedling or sapling in structure, referred to as plantations) would be pre-commercially thinned. Although these stands currently provide for moderated fire behavior as described in the existing condition, an indirect effect of not treating them could be realized over the longer-term. As the young trees continue to grow, added competition and other stress can increase mortality – abundant dead fuels create control problems for fire suppression resources in the event of a wildfire. The current effectiveness of these plantations (older regeneration harvests) will eventually lapse due to fuel accumulations and other stand changes (Agee 2002).

Table 3 – Resource indicators and measures for Alternative 1

Resource Element	Resource Indicator	Measure	(Alternative 1)*
Surface Fuels	Fuel Models & Fuel Loads	Flame Lengths (Feet)	4-8 feet
Ladder Fuels	Canopy Base Heights	Probability of Torching (%)	>95%
Canopy Fuels	Canopy Bulk Density	Crowning Index (Winds in mph)	<15 mph

*The values in Table 3 represent the average fire/fuels conditions of a forested stand which has no record of past management and would receive no treatment under Alternative 1. See discussion above.

Maintaining fuels conditions that contribute to a high probability of torching, coupled with low-winds necessary for active crown fire perpetuates the risk of losing dry-forest old growth during a wildfire. If a stand-replacing wildfire occurs, we could expect all old trees could be killed (Abella et al. 2007).

Alternative 2 (Proposed) and Alternative 3 (No Activities in Roadless)

Both action alternatives include vegetation management utilizing regeneration harvest (shelterwood, seed tree, and group selection) followed by fuels reduction (pile burning or underburning), prescribed fire only treatments, a fuel break, and pre-commercial thinning. However, the alternatives vary in the amount of acres treated. Alternative 2 includes thousands of acres of prescribed fire only treatments across the landscape, whereas Alternative 3 proposes just 172 acres of prescribed fire only as no activities would occur in roadless (where most burn only treatments are proposed).

Table 4 – Acres of treatment by alternative

Treatment Type	Alternative 2 (Proposed Action) Acres by Treatment	Alternative 3 (No Activities in Roadless) Acres by Treatment
Regeneration Harvest & Burning	3,433	3,433
Prescribed Fire Only	7,407	172
PCT	806	806

Fuel Break	22	22
Total	**11,668**	**4,433**

Alternative 2 proposes treatments which would have a direct effect on fuels on a total of 1,909 acres of WUI (about 22% of the 8,700 acres of WUI in the BCRP area). Alternative 3 proposes treatments which would have a direct effect on fuels on approximately 1,282 acres of WUI (just under 15% of the BCRP WUI). The following table displays the amount of treatment that would occur in the wildland-urban interface by treatment type. Both alternatives propose the same treatments in the vicinity of the Black Mountain tower and communication site.

Table 5 – Treatment occurring in WUI for each action alternative

Treatment Type	Alternative 2 (Preferred) Acres in WUI	Alternative 3 (No Harvest Roadless) Acres in WUI
Regeneration Harvest & Burning	924	924
Prescribed Fire Only	627	0
PCT	336	336
Fuel Break	22	22
Total	**1,909**	**1,282**

Prescribed fire only treatments were proposed to return the role of fire disturbance to the Boulder Creek ecosystems, to create a mosaic of stand structures and reduce fuels to provide for increased fire management options in the future. These burn-only treatments would likely occur over the course of several burn seasons (burning could occur in the spring or late summer/early fall) depending on fuel and weather conditions. Although more than one burn unit may be ignited during a single burn operation, completion of all burn only units is expected to take several years. Burning of both natural and activity fuels would only occur if they can be implemented in accordance with the parameters of fuel, weather, and other conditions specified in a line officer approved burn plan. In addition, ignition of prescribed burns would occur when fire managers believe objectives have a high probability of being met and when risk of escape is low.

Direct and Indirect Effects - Alternative 2

Surface Fuels and Flame Lengths

Regeneration Harvest and Fuels Treatments

Surface flame lengths associated with the current condition, in stands that have no record of past management, average 4-8 feet. Following an initial mechanical treatment to harvest the overstory, the units would be prescribed burned either through pile burning or underburning. The application of prescribed fire is considered one of the best methods to reduce surface fuels and modify fire behavior (Graham et al 1999; Pollet and Omi 2002, Stephens et al. 2009) such as reducing the likelihood of crown fires (Van Wagner 1977). Following these treatments, surface fuels will be most similar to a TL1 (where prescribed underburning occurs) and TL3 (where piling and prescribed pile burning occurs). The primary carrier of a fire in a timber stand characterized as a TL1 is compact forest litter. The fuels are light – the timber litter fuel load would likely be reduced by about one-half to two-thirds and the fuel bed depth would likely be just 1 to 2 inches deep. These low fuel load conditions, both TL1 and TL3, translate to low surface flame lengths of about 1-2 feet.

It is important to note that in the short time between harvest and prescribed burning, predicted flame lengths would actually increase above even the current condition due to the addition of slash from logging activities (limbs, tops, breakage from felling and skidding operations). Once the slash is treated, however, predicted flame lengths would decrease below 2 feet (as shown in the graph below). As the regeneration develops in the understory, the surface flame lengths would be expected to rise slightly, but decrease again as the trees grow up out of the surface fuels. Regardless, throughout the scenario, surface flame lengths stay below the desired threshold of 4 feet.

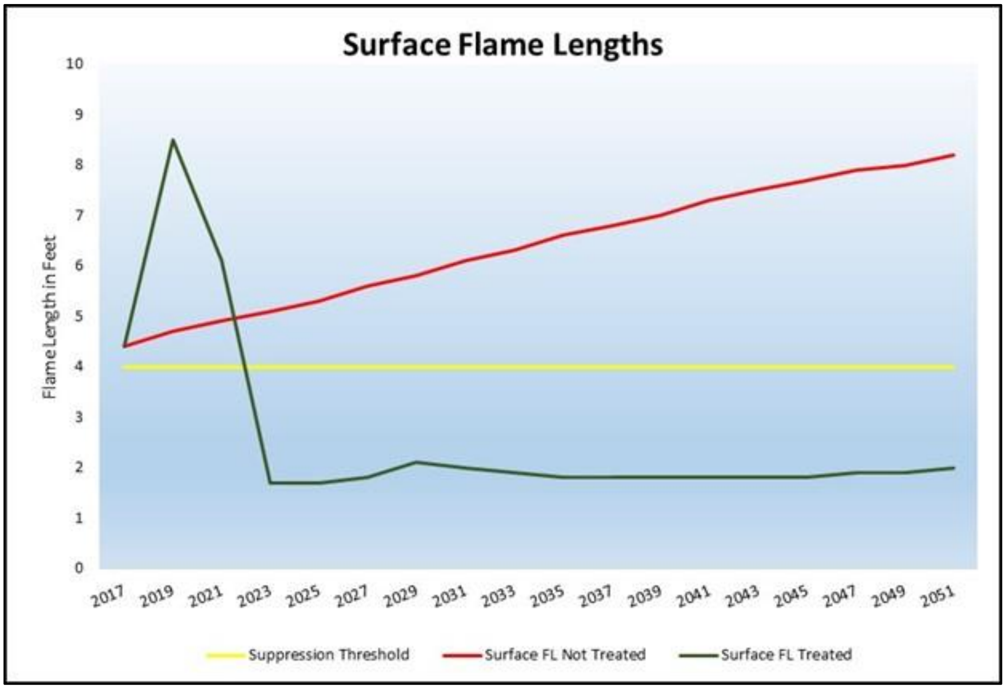


Figure 8 – Comparison of predicted surface flame lengths over time. Harvest and Fuels Treatment vs. No Treatment, for a representative stand in the project area (Stand 74704020, Unit 236). The yellow line is added to highlight the 4 foot threshold where it is safe for ground firefighters to directly attack a fire.

Severe effects are often associated with crown fires, however, even a surface fire burning in heavy ground fuels can lead to soil damage, tree mortality, and smoke impacts. Smoldering fires and residual combustion can transfer large amounts of heat deep into the soil (Graham et al. 2004,). Thus anywhere surface fuels are heavy, even in areas where crown fire potential is low, there could be undesired effects. Specific to our drier forests, research suggests thinning of the overstory through harvest followed by burning can mitigate wildfire severity (as compared to no treatment or thinning only) (Prichard et al. 2010).

Prescribed Fire Only

At the stand-scale, prescribed burning has been shown to reduce subsequent tree mortality, crown scorch, and exposed and blackened soil (Finney et al. 2005). Burning treats the surface fuels, which is of great importance for treatment effectiveness (Martinson and Omi 2013) to reduce future burn severity (Prichard and Kennedy 2014). This reduction in subsequent burn severity is a result of decreased fire intensity (lower flame lengths and rates of spread).

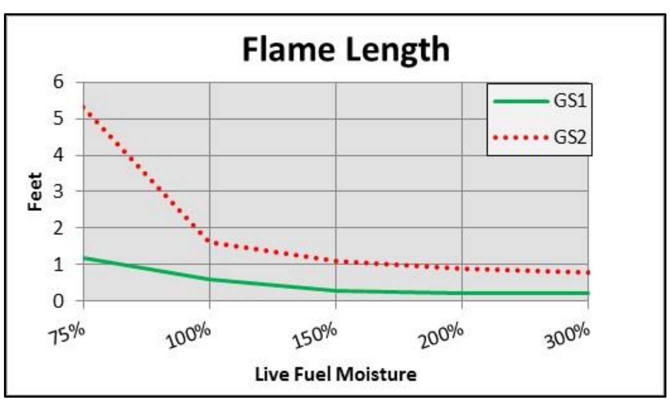
Prescribed fire can effectively alter potential fire behavior by influencing multiple fuel bed characteristics (Graham et al. 2004, page 24), including:

- Reducing the loading of fine fuels, duff, large woody fuels, rotten material, shrubs and other live surface fuels, which together with compactness and continuity change the fuel energy stored on the site and potential spread rate and intensity.
- Reducing horizontal fuel continuity (shrub, low vegetation, woody fuel strata), which disrupts growth of surface fires, limits buildup of intensity, and reduces spot fire ignition probability.
- Increasing compactness of surface fuel components, which retards combustion rates.

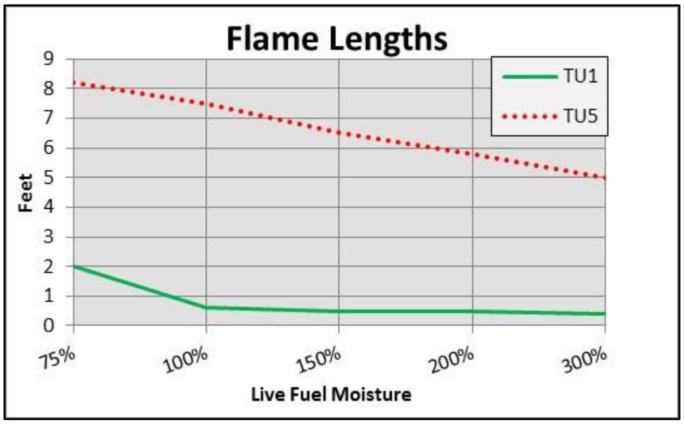
A lot of proposed burning would occur in areas dominated by tall shrubs and hardwoods, with little timber overstory aside from individual or clumps of encroaching timber (from a century of fire suppression). These shrub dominated ‘openings’ account for approximately 40-50% of the prescribed burn only acres. Applying controlled fire in these areas would be done with the intent of killing the encroaching timber while revitalizing the decadent shrubs (encouraging re-sprout through top-kill) in order to maintain the openings for habitat into the future.

Figure 9 – Before and after prescribed fire. Shrub fields, like those present in the Boulder Prescribed Fire Only areas, before and after burning

Key changes brought about by burning shrub fields (currently GS2 fuel models) include the reduction of total fuel volume, reduction of fuel bed depth, and the increase in the ratio of live to dead fuels. Following prescribed burning, all components of surface fuels (including a portion of the duff) would be reduced. GS2 stands would still be grass and shrub dominated, but have a lower load and be similar to a GS1 (shorter shrubs), where predicted flame lengths are within the desired range of <4 feet (compare in the figure below under periods of very high fire danger where live fuel moistures start to drop well below 100%. Live fuel moistures at 300% occur in the spring following green-up).



Burning would also occur in dense mature timber occurring mostly in the backcountry, and primarily at higher-elevations. Depending on the intensity of the prescribed burns, and how well fire carries through certain areas, the degree to which surface fuels are reduced could be more variable under a timber canopy. Generally, where fire carries through areas of heavy fuel TU5, the result would be a TL3, TL1 or TU1, especially in the short-term. Reducing surface fuels would result in reduced expected flame lengths from about 8 feet down to 2 feet.



In the dense stands outside of old growth, the intent of the burning would be to create patches of high-intensity fire to creating openings of roughly 10 acres (could be more or less), disrupting the continuity of structure in these areas. A trade-off of in causing intentional mortality in these patches, would be long-term large woody fuel accumulation as the dead trees begin to fall. This would happen over the long-term, approximately 10-20 years post-burn. This increase in coarse-woody debris is common in stands where the prescribed burn is the first fuel treatment occurring in the mature stand in decades – the fire kills many small trees which contribute to the woody fuel load (Graham et al. 2004). In the long-term, the increased fuel loading of this material could contribute to flame lengths similar to TU5 again (up to 8 feet). An important consideration is that ladder and canopy fuels would be reduced, as would the other surface fuel components, small timber litter, decadent shrubs, small trees, and duff. In addition, the prescribed burn treatments to create openings in the canopies occur in the backcountry, outside of desired old growth patches, occurring as 10 acre areas (plus or minus) within much larger prescribed burn areas (hundreds of acres).

Precommercial Thinning

All of the PCT would be accomplished by forest workers hand-thinning the cut trees using chainsaws; the material would be left on site with no mechanical treatment of the cut material to follow. This could result in a short-term increase in the fire hazard within the stands because the thinned material would be small diameter woody fuels and arranged in a generally continuous matter, facilitating fire spread. Following thinning surface fuels would be most similar to a light slash fuel model or SB1 (SB is slash-blowdown with fine fuel loads from 10-20 tons/acre with a fuel depth of about 1 foot). Fires can be active in the slash and intermixed herbaceous material exhibiting moderate spread rates (5-20 chains per hour) with generally low flame lengths (<4 feet), grading to moderate (up to 8 feet) where fuels are more concentrated. Where surface flame lengths do exceed 4 feet, the threshold for utilizing direct attack suppression tactics by hand crews on the ground would be exceeded. Utilizing the design features fire behavior would be moderated and after the fine needles have fallen and decomposed flame lengths would drop to between 1-3 feet – within the range of direct attack.

Figure 10 – Seven year old precommercially thinned stand. Note there are very few woody fuels and what remains has been compacted and intermixed in the ground fuels. The primary carrier of fire in this stand is no longer the slash fuels, but primarily small shrubs and grasses.

Monitoring of previously thinned stands across the north zone of the Idaho Panhandle National Forest indicates fire hazard from precommercial thinning slash is naturally mitigated after approximately 5-7 years following thinning. Fine fuels have long fallen and stems and branchwood have become incorporated into the ground and decomposition of this material has occurred. Following treatment and natural mitigation, surface fire behavior would be lessened as compared to the pre-thinning units; after 5-7 years surface flame lengths would be consistent with the desired condition fuel model TL3 (<2 feet).

For long-term fire management, treating these plantations now may be important for at least two reasons. Regeneration harvests that are two or more decades removed from the time of entry have fuels structures that in time would contribute to crown fire potential if left without further management (Agee and Skinner 2005). Secondly, without treatment, high stand density limits site nutrients, water, and sunlight often affecting growth and vigor of the stand due to high levels of competition; PCT treatments are intended to increase growth and vigor and overall health of residual trees through stocking control (see Vegetation report). In the long run, it stands to reason that a healthy stand (where stocking and competition is reduced and more fire tolerant species are favored) will be a more fire resilient stand. Therefore, accepting a short-term increased spread potential and flame lengths along with the benefit of the health and vigor of the young stands needs to be weighed against taking no action now and dealing with an accumulating fire hazard into the future.

Ladder Fuels and Probability of Torching

Regeneration Harvest and Fuels Treatments

Following harvest and prescribed burning, canopy base heights would be near 30 feet (to the base of the crowns of the residual large trees); these activities remove nearly all ladder fuels, small-diameter trees, and much of the dominant overstory. This is well beyond the level needed to inhibit torching, especially in consideration of the predicted low surface flame lengths. With such high canopy base heights, the winds necessary to initiate torching would be unreasonably high (>100 miles/hour), thus the estimate of torching probability would be 0%. A low torching potential, below 20%, would be realized for 20-25 years until the regenerating understory trees were of a certain height where they would be considered ladder fuels to the residual tree crowns.

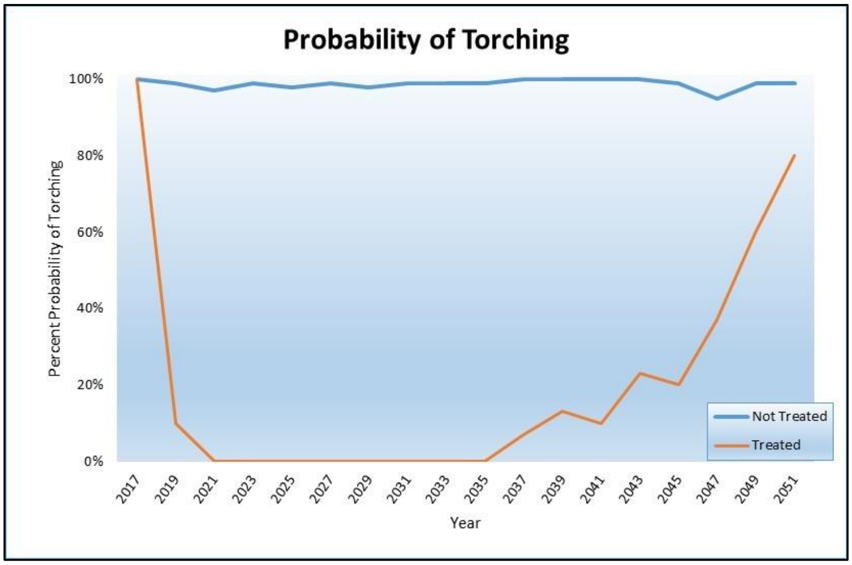


Figure 11 – Comparison of predicted probability of torching. Harvesting with Fuels Treatment vs. No Treatment for representative stands in the project area.

Prescribed Fire Only

Where burning occurs under a timber overstory (approximately 50-60% of the proposed burn areas), probability of torching is not expected to decrease to as great a degree as where harvest and burning occurs. Prescribed fire only treatments raise the height to live crown base by scorching lower branches (Valliant et al. 2006), consuming tall shrubs, and killing small trees. However, these fuels would not be reduced or removed uniformly across the burn area.

Harvest can be more intentional in the exact ladder and canopy fuels removed per marking guides and a logging plan that is followed during operations. Additionally, after harvest, a fairly uniform fuel load is left in which prescribed fire is then carried through. With the prescribed burn only treatments, not every acre is expected to burn, and not every acre is expected to burn with the same intensity due to variations in fuel loading. Rather, the expectation is a mosaic of burned patches and unburned patches, within the larger treatment area.

Simulations of prescribed fire within a lower elevation dry-site stand (such as burn unit 5) showed canopy base heights increasing to about 30 feet and the probability of torching decreasing to 15%, post-burn; those conditions were maintained out 40 years. For a higher-elevation subalpine stand (such as burn unit 1), where current ladder fuels are very abundant, canopy base heights were increased to just under 30 feet and the probability of torching decreased from 97% in the current condition down to just over 40% following the prescribed fire.

Precommercial Thinning

Canopy base heights of the residual trees would still be very low (<2 feet, refer to Figure 10) so torching of individual trees would be expected during a fire. In the long-run, as the residual trees grow, canopies will rise up off the forest floor and trees will shed lower branches resulting in a gap between the surface fuels and the tree canopies. This will result in increased canopy base heights and a reduced probability of individual tree torching (as compared to the short-term immediately following PCT).

Canopy Fuels and Crown Fire Activity

Regeneration Harvest and Prescribed Fire

A key in treating the crown fuels by harvesting overstory trees is to effectively reduce the canopy bulk density to a level where active crown fire is not possible or the chances are significantly reduced (Scott and Reinhardt 2001). In effect, the fire spread rate needed in order to sustain active crown fire is thus at an unrealistically high level. It is assumed that treatments which remove overstory trees effectively lower the CBD – for example, if 75% of the canopy fuels are removed it is assumed the canopy bulk density is decreased by approximately 75% (this relationship varies depending on species removed – if mostly shade tolerant trees with heavy crown structures are removed the remaining canopy bulk density could decrease by an even greater proportion).

Simulating a regeneration harvest in a representative stand, the canopy bulk density would drop from 0.16 kg/m3 to about 0.03 kg/m3 (80% reduction). Even if crown fire initiation (torching) were to occur, harvest of the overstory trees would effectively space tree crowns, reducing the likelihood of fire spread from one tree to the next. This is because horizontal continuity of the remaining timber is reduced, as is the canopy bulk density, through the harvest of overstory trees. The increase in the crowning index (winds necessary to sustain active crown fire) from 13mph in the untreated stand to >60mph following harvest results in surface fire being the type of fire expected and not active crown fire, even under periods of very high fire danger. This could remain effective for decades into the future, until regeneration becomes incorporated enough into the overstory to facilitate fire spread once again through the canopy (Figure 12).

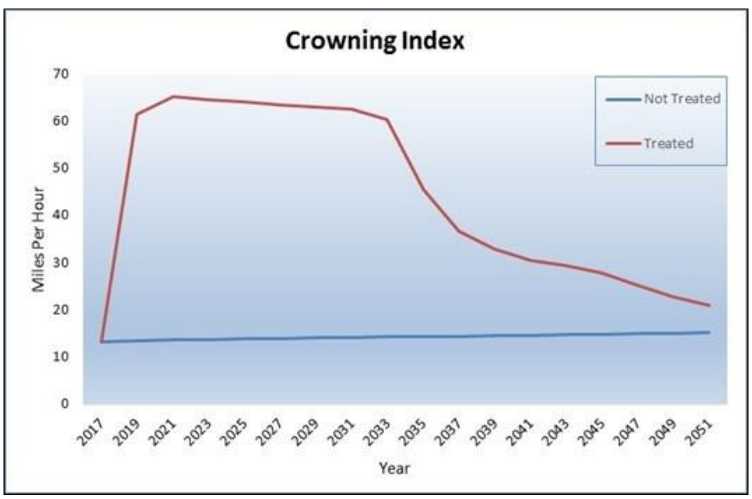


Figure 12 – Comparison of predicted Crowning Index. Harvesting with Fuels Treatment vs. No Treatment for representative stands in the project area.

Under the current condition, if fire is able to transition from the surface fuels into the canopy fuels and burn as active crown fire, total flame lengths could exceed 80 feet. Fires with such high intensities have a resulting high resistance to being controlled by firefighting efforts. Research suggests restoration treatments which thin the overstory and burn the surface fuels, reduce stand density, torching hazard and crowning hazard as compared to thin only or control treatments (Fiedler et al. 2010). In a simulation for this project, reducing the surface, ladder, and canopy fuels, reduced the potential for torching and active crown fire to a level that the predicted surface flame lengths are also the predicted *total* flame lengths (<4 feet). These are within the desired conditions for reduced intensities and the ability to attack a fire with direct suppression using ground forces.

Indirectly, opening a stand with timber harvest could result in increased surface winds as compared to adjacent dense stands (Agee and Skinner 2005). This could result in increased rates of spread and flame lengths at the surface. Scott and Reinhardt (2001) address this:

"The increased fuel-level wind speed coupled with increased insolation (exposure to sunlight) also leads to lower dead fuel moistures in treated stands during the summers. These two factors tend to exacerbate surface fire behavior. However, properly executed treatments also tend to reduce the crown fire potential. Crown fire mitigation treatments often represent a tradeoff – the decreased crown fire potential comes at the expense of increased surface fire spread rate and intensity. The greatly increased spread rate and intensity of crown fire makes this tradeoff reasonable."

Prescribed Fire Only

As with ladder fuels and canopy base heights, prescribed fire only treatments are not expected to have as great an effect on canopy fuels and canopy bulk density reduction as harvest treatments (which leave a very specific structure and composition to the overstory). Prescribed burn only treatments would likely be much less predictable or uniform in the resulting fuels. Nonetheless, mortality is expected in individual trees and groups of trees, especially outside of old growth and where intense fire is intended to create openings in the dense timber. Applying fire in these areas could see a total stand canopy bulk density reduction of more than half (in a simulation stand, prescribed fire reduced the canopy bulk density from 0.18 kg/m3 to 0.08 kg/m3). In doing so, the crowning index would be increased from around 13 mph up to 26 mph. If a future fire were to transition from the surface to the canopy fuels, 26 mph winds are not unreasonable. However, following prescribed burning which meets project objectives, surface fuels and ladder fuels would be expected to be reduced to such a degree that transition to crown fire (torching) would be reduced when all factors contributing to it are considered together.

Precommercial Thinning

By treating the pre-commercial thin units an additional fire hazard reduction would be realized above the current condition through a reduction in tree density by as much as 90%. Fewer trees per acre would result in spaced tree canopies and a reduced CBD (as compared to if no PCT occurred) as the trees mature, limiting fire spread from tree to tree now and into the future.

Table 6 – Resource indicators and measures for Alternative 2

Resource Element	Resource Indicator	Measure	Alternative 2 Direct Effects
Surface Fuels	Fuel Models & Fuel Loads	Flame Lengths (Feet)	<4 feet
Ladder Fuels	Canopy Base Heights	Probability of Torching (%)	0-40%
Canopy Fuels	Canopy Bulk Density	Crowning Index (Winds in mph)	26 to >60 mph

Proposed Treatments near Black Mountain

The untreated fuels around the Black Mountain lookout and communication site are consistent with high elevation mature colder forests. Subalpine fir, spruce and lodgepole are found growing in a very dense manner with grasses, brush and scattered (often heavy) woody fuels occupying the forest floor. Coarse-woody debris easily exceeds 50 t/a in some areas of these stands. This fuel structure and arrangement allows for fire spread on the ground through the surface fuels until the flames reach the low canopies and then individual or groups of trees torch throwing embers out in front with the direction of spread or wind. This pattern of fire spread is repeated – a series of torching, spotting, and torching ahead of the main area burning.

Proposed activities adjacent to Black Mountain includes 133 acres of harvest with fuels reduction treatments with an additional 22 acres where a fuel break would occur (as described below). These 155 acres of treatments tie into an additional 60 acres of past harvest (see figure below). The proposed activities would likely not stop a fire, but slow the spread by reduce torching and spotting potential, and receptivity of fuels if a fire spots *into* these stands, allowing for greater success of direct attack and protection at the communication site.

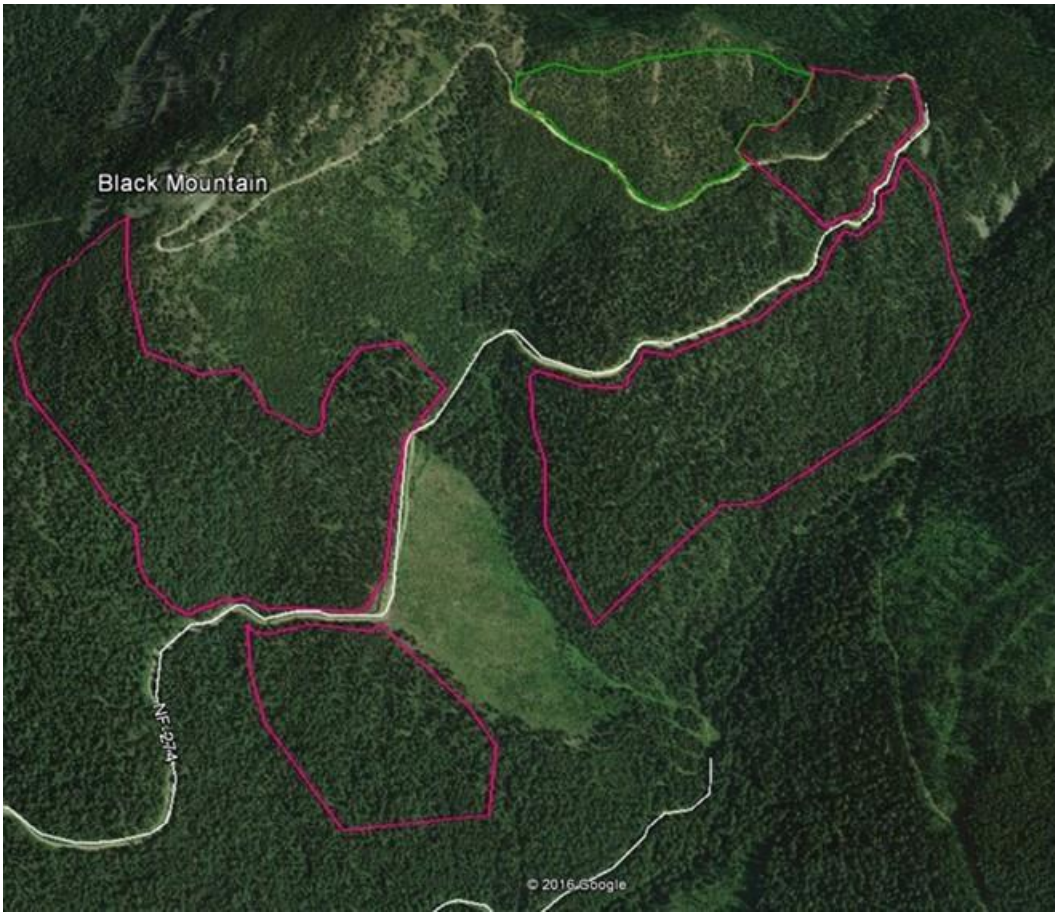


Figure 13 – Proposed treatments near Black Mountain WUI. Harvest units (pink) and fuel break (green). The proposed treatments tie together with past treatments, resulting in a nearly contiguous treated area of 215 acres where surface fuels are either piled and burned, ladder fuels are removed, and the residual canopy is spaced. One old growth stand will not be treated – it lies south of the fuel break, below the road.

Fuel Break

The proposed fuel break is located 1/3 of a mile east of the communication infrastructure on Black Mountain in the area where the Black Mountain lookout is to be relocated. It is upslope of an old growth stand consisting of heavy surface fuels and abundant ladder fuels which will not be treated with this project. It is also on the lee-side of a ridge of very heavy fuels to the north, situated in an area where spots could land if a fire were to get established on the north aspect. Constructing a fuel break in this area would extend the treated area, tying together proposed harvests and a young regenerating stand.

The intent of a fuel break is to remove surface fuels, increase the height to the live crown of residual trees and space the crowns to reduce torching (Agee et al. 1999). As is the case with this project, they are often used along ridgelines where fire control efforts may be focused. Fuel breaks are not necessarily intended to stop a wildfire. The intent is to slow the spread and reduce the fire intensity; reduce the avenue for surface fire to move into the crowns of the trees to reduce spotting. According to Agee and others (1999), using fuelbreaks in association with larger fuel treatments can reduce the size, intensity and effects of wildland fires, while possibly providing a point of attack for suppression resources.

To accomplish these objectives, this fuel break would slash small trees (generally less than 5 inches in diameter), focusing on retention of desired species at a reduced stocking, and cut tall brush. Surface fuels would be grapple piled or hand piled (depending on slope limitations to machinery) and then the piles would be burned.

Proposed Activities to Maintain Dry-Site Old Growth

In fire-dependent ecosystems, especially those containing old growth, it is important to acknowledge that in the long-run fire suppression may be unsustainable (Abella et al. 2007) and undesirable; fuel accumulation, competition stress, insects and disease, and the eventual fire may destroy the old growth (Binkley et al. 2007). This makes fuels reduction important, even where these stands occur outside the WUI. During high fire danger conditions, it could be difficult to prevent large fire occurrence and development, especially across homogenous landscapes. Reducing the potential severity when a large fire does occur may save ecosystem elements conditioned to historical fire (Reinhardt et al. 2008), such as large old ponderosa pine. Management activities such as controlled burning are being designed to initiate an improvement trend; these forests are stable in the long-term, as long as fire is maintained in the system (Binkley et al. 2007).

Prescribed burning in the dry-site old growth stands (burn units 2 and 3 total 115 acres) would be conducted with the purpose of maintaining these stands as old growth now and into the future. Low-intensity prescribed burning, where flame lengths and spread rates are controlled, could be accomplished under more moderated weather and site conditions than would occur during fire season. The burns would be designed to consume surface fuels (such as grass, small shrubs, and jackpots of down woody fuel) and ladder fuels (tall shrubs, small conifers, and possibly lower branches of bigger trees), while minimizing damage to the overstory. Accomplishing these objectives would likely result in fuels conditions where subsequent wildfires burn with less intensity and potential severity to the stand.

Where burning only occurs, some slashing of the understory would be necessary first in order to accomplish burn objectives. Slashing smaller trees and tall brush would help carry fire through the stand while also removing fuel from around the large old growth trees (ponderosa pine and some Douglas-fir and western larch), protecting them during the application of prescribed fire. These two burn units generally have a more open crown structure, due to site conditions, than the surrounding units. However, without first prepping the stand to remove fuels around the larger trees, a burn would have to be conducted under such moist conditions with such low-intensity (so as not to risk damage to the old growth) that adequate surface and ladder fuels reduction would likely not be accomplished.

Treatment Size and Location

In addition to considering the condition of fuels at the individual stand, it is also important to evaluate conditions across the landscape. It is at the larger landscape scale that treatments have more potential for disrupting large fire growth and reducing fire movement. These are important considerations when managing forests for reduced risk of large scale stand-replacing fire, regardless of whether they are located in the WUI or not. A fire burning outside the WUI may not stay there; untreated fuels may allow for large fire development and fire intensities that move a fire quickly and uncontrollably into an area where values are at risk. In recent years, it has been recognized that the spatial arrangement, size and amount of landscape treated can be important factors in how fast and intense a large fire can burn through a forest (Finney 2001, Finney et al. 2007, Finney et al. 2005, Weatherspoon and Skinner 1996).

In a study of actual wildfire behavior, Finney et al. (2005) noted that fire severity decreased more in larger treatment units as compared to smaller ones, and decreased more as one went from untreated areas further into areas that had been treated. Treating the backcountry adjacent to the WUI (such as the Paradise Valley Community watershed just north of the analysis area) with large landscape burns could slow the spread of a future fire from the treated area into the WUI. Small and scattered fuels treatments are less effective at fragmenting fuel loads across a landscape and may be overwhelmed by intense fires burning in adjacent areas (Agee and Skinner 2005).

In addition, researchers have found that larger treatment units could be more effective than smaller ones because fires burning up to larger treatments would be less likely to spot across the treatment area into untreated fuels (Weatherspoon and Skinner 1996, Van Wagtendonk 1996). Lastly, in respect to the resource concerns near Black Mountain, larger treatment areas here could better serve as fuel breaks where suppression resources could engage the fire more safely and under more severe conditions. In regards to how fuel treatments can influence the behavior of large fires at the landscape scale, Graham et al. (2004) concluded that treating small or isolated stands without addressing the broader landscape will most likely be ineffective in reducing fire extent and severity, if that is of concern.

Treatment Longevity

Forests are in a constant state of flux and succession is continually moving stands either towards or outside the range of desired conditions; in western forests, productivity generally exceeds decomposition (Reinhardt et al. 2008). Observations and general knowledge of forest succession tells us that the benefits of one entry treatment would not last indefinitely. In fact, there is evidence that the benefits of an initial treatment can wane as early as a decade in very productive forests where fuels build up quickly (Agee and Skinner 2005). Regeneration harvest would leave very little overstory, therefore treatments would be expected to last a bit longer. In addition, it is possible the effects of one entry would last longer on less-productive dry-sites – evidence from Yosemite National Park indicates that most natural fires stop at old fire boundaries 15-years old (Agee and Skinner 2005). At any rate, it is acknowledged that in time treated areas will once again have fuel structures that would contribute to crown fire potential if left without additional management (Agee and Skinner 2005); this goes for past treatments and the ones proposed with this project. The silvicultural prescriptions should include objectives for maintaining low hazard fuels and reduced fire behavior into the future where it is desired.

Road Management

A Travel Analysis Process was conducted by the interdisciplinary team and the result was to recommend road storage and a small amount of road decommissioning for both alternatives.

When a road is stored or decommissioned it is made hydrologically inert and impassible by motorized vehicles (including high-clearance four-wheel drive pickups, motorcycles, and 4-wheelers). Methods to accomplish this are numerous and include berms, gates, installation of waterbars, pulling culverts and ditch-relief systems, planting native grasses and vegetation, etc.

Though no direct effects to the fire and fuels resource as a result of these activities are anticipated, an indirect effect would be less timely access by fire personnel in the event a wildfire occurs. The road recommended for decommissioning is currently not drivable and therefore, would not affect the current access. However, putting some of the proposed roads into storage would result in reduced vehicle access (including fire engines) in the event of a wildfire in those areas, potentially affecting suppression response times, fire growth and size and fire costs. This would be specific to roads 1304G, 2662, and 2113A; reducing access for suppression in the WUI (roads 2662 and 2113A) makes the proposed treatments to reduce fuels and potential fire behavior in these areas even more critical. The other roads proposed for storage are either not currently accessible or provide only minimal land access, so storing them are of little concern from a fire management perspective.

Although access may be reduced with either storage or decommissioning, storage is preferred for the fire/fuels resource because even though both activities have the same positive benefit for aquatics, wildlife and other resources, a stored road remains part of the road system whereas a decommissioned road does not. Therefore, a stored road can be reopened and made drivable again in the future if a need arises, especially in an emergency, such as for wildfire suppression. Any road maintenance that occurs associated with the project would be beneficial for fire management due to safer driving conditions for resources.

Direct and Indirect Effects of Alternative 3 (No Activities in Roadless)

The direct and indirect effects of Alternative 3 would be the same as has been described for Alternative 2 for nearly all treatments, however, far fewer acres would be treated by ‘prescribed fire only.’ As no activities would occur in roadless, Alternative 3 includes just 172 acres of burn only units, as compared to 7,400+ for Alternative 2. Therefore, under Alternative 3 the effects of prescribed burning only treatments are limited and mostly just applicable at the stand-scale (rather than having landscape fire and fuels benefits), as described above.

Table 7 – Resource indicators and measures for Alternative 3

Resource Element	Resource Indicator	Measure	Alternative 3 Direct Effects
Surface Fuels	Fuel Models & Fuel Loads	Flame Lengths (Feet)	<4 feet
Ladder Fuels	Canopy Base Heights	Probability of Torching (%)	0-40%
Canopy Fuels	Canopy Bulk Density	Crowning Index (Winds in mph)	26 to >60 mph

Outside of roadless, just two units would be burned – unit 4 would prescribe burn 73 acres and unit 12 would prescribe burn 99 acres. Both burn units are dominated by brush and grass fuels and the effects of burning on surface fuels would be similar as has been described for those fuels. Unit 4 consists of mostly dense shrubs under a timber overstory that was harvested in the late 1990s. Burning this unit would result in surface fuels reduction from a GS2 to a GS1, where predicted flame lengths are in the desired range of <4 feet. Burning back the tall shrubs removes those that are serving as ladder fuels to the residual overstory trees. In unit 4, the intent would be to treat surface and ladder fuels and get a cycle of fire back in the stand, while minimizing mortality to the overstory trees similar to burning in old growth. Therefore, there would be minimal effect to the existing canopy bulk density or crowning index, both of which are already in desired range.

Unit 12 is a mix of grass and shrub meadows, but also dense lodgepole dominated timber. Prescribed burning would be expected to modify GS2 fuels to GS1, kill encroaching timber in the meadows, and result in effects in the timber dominated areas similar to what has been described in regards to burning effects on surface, ladder and canopy fuels. Fuels models would generally be reduced from a TU5 to a TL3 resulting in surface flame lengths <2 feet. In the dense timber, canopy base heights and probability of torching, as well as CBD and crowing index would be reduced similar as described in the direct and indirect effects of prescribed burning only for Alternative 2.

Cumulative Effects – Alternatives 2 and 3

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

In the BCRP area, activities which would contribute to cumulative effects under the action alternatives are fire suppression and fire use, timber harvest, the North Zone Roadside Salvage project, precommercial thinning (PCT), and prescribed burning, because these activities have both a direct and indirect influence on fuels conditions. The majority of activities, such as public use, noxious weed treatments, tower and trail maintenance, helispot maintenance, mining activities, and public activities, are not expected to have cumulative impacts to fuels, as effects would be minor or likely immeasurable. It is possible that on-going and future road maintenance activities could reduce fuels in areas susceptible to human starts as well as providing access and maintaining safe conditions along travel routes into the future, as described in the indirect effects of the action alternatives.

Vegetation Management

When combined with this project, ongoing and future timber harvest and fuels treatments, such as the Leonia project, would decrease surface, ladder, and canopy fuels across an even larger proportion of the BCRP landscape. This would increase the area where the potential for stand-replacing fire is reduced, including within the WUI and dry-site old growth. In regards to the protection of the communication infrastructure on Black Mountain, the ongoing Twentymile project adds to the protection of the site from fire starting to the west of the facilities. Any PCT within the BCRP area additional to what is proposed, would increase surface fuel hazard in the short-term on more acreage, if the cut trees are not piled and burned, similar to the proposed action.

The North Zone Roadside Salvage Project would involve the removal of trees from along designated roadsides, resulting in some fuels reduction along open roads, which are prone to fire starts. This could help slow fire spread into adjacent stands if a fire were ignited. Additionally, safety along ingress and egress routes would be increased in these areas for both firefighters and the public.

Wildfires and Fire Suppression

The exact time and location of future wildfire ignitions are unknown, but both human and natural ignitions are considered inevitable. Treatments may be effective at reducing fire behavior and severity, but not necessarily a reduction in occurrence (Reinhardt et al. 2008). In addition, the presence of WUI values, and other potential values at risk, means many future fires in the BCRP area will be suppressed. Past fire suppression has contributed to the fuel characteristics we see today, therefore, future fire management policy which includes fire suppression would be expected to affect fuels conditions into the future. Alternative 2 proposed to treat almost 30% of the BCRP landscape (just 11% for Alternative 3), which will help interrupt the effects of continued fire suppression on fuel accumulations. With either action alternative, fuels would be reduced, early seral and more fire tolerant species would be promoted, and open canopy structures would be favored. If over the long-run we continue to suppress fires, reducing potential severity when it does occur may reduce fire effects (Reinhardt et al. 2008) to values at risk and the residual stands.

Summary

In regards to the WUI and other values-at-risk (old growth, for example), the reasons we suppress wildfires are the same reasons management activities to reduce fuels are being proposed in these areas. Fire effects can be undesirable where WUI and other values occur and a pro-active measure to reduce fuels and the acres where severe surface or crown fire is possible is advantageous to mitigate safety concerns to the public and firefighting resources, protect infrastructure, and minimize severe fire effects to resources.

In addition, treatments (such as harvest and prescribed fire) which reduce fuels outside of the WUI have value in the consideration of future fire management. Although the IPNF recognizes the importance of utilizing natural fire to accomplish resource objectives, there could be risks associated with letting natural fire burn under conditions of high fire danger (hot, dry, windy conditions). This would be an important consideration where fire is expected to behave outside of the historic fire regimes under which some of these forests developed. In regards to the prescribed burn only treatments, large unit size, strategic placement, and extent of the burning could help trend towards desired vegetation conditions with the added benefit of reducing fuels and affecting subsequent fire spread at the landscape scale. Management of vegetation across a large area can create a mosaic of fuel interruptions that can reduce the size and spread potential of wildfires (Brackebusch 1973). Evidence that mosaic patterns reduce fire spread comes from natural fire patterns that have fragmented fuels across landscapes (Graham et al. 2004). Applying harvest and fuels reduction treatments along with large scale planned ignitions, accomplished in a controlled manner, could provide more flexibility for future decision makers to utilize unplanned natural ignitions to accomplish additional resource objectives.

The huge Rodeo-Chediski fire was observed to actually circumvent treated areas, even under extreme burning conditions, leaving unburned inclusions as the fire was actively spreading. Research by Finney et al. (2005) suggests fire growth and severity of a large wildfire under extreme weather conditions were mitigated by fuel treatments that included prescribed burning. Prichard and Kennedy (2014) add that prescribed burning of surface fuels can mitigate subsequent burn severity. Prescribed fire reduces surface fuels and can mitigate subsequent burn severity (Prichard and Kennedy 2014); at least temporarily reducing the likelihood for future intense surface fires or surface fires propagating into tree crowns (Graham et al. 2004). Longevity of treatment benefits was suggested to improve with unit size. Observations of fire movement near fuel treatments indicate that overall fire growth and large fire sizes of subsequent wildfires can be reduced (Finney et al. 2005).

Lastly, virtually all climate-model projections indicate warmer springs and summers will occur in the west in coming decades (Whitlock et al. 2003). Research by Westerling and others (2006) suggests increased large wildfire activity in the Northern Rockies is strongly associated with increased spring and summer temperatures and earlier spring snowmelt. Even for a very low-end climate change scenario, it seems likely that the area burned annually will approximately double by the end of this century in most western states (McKenzie et al. 2004). It reasons that managing for reduced fuels, favoring more fire resistant species, and creating variation in forest structures across the landscape, is a positive step towards maintaining desired conditions in the face of potentially more and larger fires.

Degree to Which the Purpose and Need for Action is Met

Both action alternatives propose activities which would reduce surface, ladder, and canopy fuels such that the potential for severe surface fire, torching probability, and the potential for active crown fire is reduced across the landscape. These activities would increase the resistance to stand replacing fire at the treatment unit, and likely to adjacent untreated areas. Both alternatives 2 and 3 treat fuels near the Black Mountain communication infrastructure and tower, helping to meet the purpose and need of protecting it from wildfire damage. Natural fuels burning (prescribed fire only) would be conducted to meet a variety of project purpose and needs, such as creating and maintaining openings, reducing fuels in old growth to protect it from future wildfire effects, and stimulating new growth to benefit habitat. Alternative 2 would return this role of fire across a large proportion of the landscape, whereas, Alternative 3 only proposes natural fuels burning on 172 acres (none of which would occur in the vast roadless area). Therefore, project needs would not be as well achieved with the small amount of natural fuels burning which would occur under Alternative 3 (for example, no old growth stands would be treated with fire only).

Table 8 – Summary comparison of how the alternatives address the purpose and need

Purpose and Need	Indicator/Measure	Alt 1	Alt 2*	Alt 3*
Increase resistance to stand-replacing fire	Acres where surface, ladder, and canopy fuels are reduced through harvest and follow-up fuels treatments to reduce potential severe fire behavior in future fires.	0	3,433	3,433
	Acres of fuels reduced in dry-site old growth such that resulting fire behavior is reduced	0	291	173
Reduce hazardous fuels around Black Mountain	Adjacent acres treated in the WUI	0	155	155
Return role of fire to BCRP ecosystems (will also help increase resistance to stand-replacing fire)	Acres where fuel continuity is disrupted and a mosaic of stand structures are created.	0	7,407	172

Summary of Environmental Effects

Table 9 – Summary comparison of environmental effects to Fire/Fuels Resource

Resource Element	Indicator/Measure	Alt 1	Alt 2	Alt 3
Surface Fuels	Fuels & Expected Flame Lengths (in Feet)	No treatments would occur and high loads of grass/shrub dominated and heavy timber understory fuel models would persist (GS2 and TU5). Jackpots of heavy down wood, which contribute to severe surface fire and smoldering would also remain (in areas >30-40 tons/acre). With Alternative 1, predicted surface flame lengths would be approximately 4-8 feet. The desired condition is <4 feet for direct attack in the event of a fire. In the small areas that do currently have fuel loads and predicted flame lengths within the desired condition, lack of disturbance will lead to continued fuel accumulation.	Harvest and fuels treatments would reduce surface fuels to be consistent with either a fuel model TL3 or TL1, where down wood is retained at desired levels by habitat type and timber litter is light. With these conditions fire spread would be slow and flame lengths would be within the desired condition (1-2 feet). Where prescribed burn only treatments occur, fuels would be reduced within the larger treatment units as a mosaic – some patches burned and others left unburned. Overall, surface fuels would be reduced to a GS1, TL1 or TU1; all of which have low loads of grass, shrubs or timber litter with resulting very low to low flame lengths (1-4 feet)	Harvest and fuels treatments would reduce surface fuels to be consistent with either a fuel model TL3 or TL1, where down wood is retained at desired levels by habitat type and timber litter is light. With these conditions fire spread would be slow and flame lengths would be within the desired condition (1-2 feet). Prescribed burn only treatments would be limited to 172 acres of treatment. In these areas surface fuels would be reduced to a GS1, TL1 or TU1; all of which have low loads of grass, shrubs or timber litter with resulting very low to low flame lengths (1-4 feet)
Ladder Fuels	Canopy Base Heights & Probability of Torching (%)	Without harvest and fuels reduction treatments, forest canopy base heights would remain on average of 5 feet (ranging from 0-10 feet) in mature and previously untreated stands. These canopy base heights coupled with surface flame lengths predicted between 4-8 feet would result in a probability of torching >95%	In harvest units where fuels reduction follows, canopy base heights would be expected to increase to ~30 feet and the probably of torching reduced to 0%. A simulation showed this condition lasting for about 15 years, then remaining below 20% out to about 25 years. This treatment would occur on 3,433 acres. For prescribed burn only units, canopy base heights are increased to just over 25 feet on average and probability of torching is reduced to between 15-40%.	In harvest units where fuels reduction follows, canopy base heights would be expected to increase to ~30 feet and the probably of torching reduced to 0%. A simulation showed this condition lasting for about 15 years, then remaining below 20% out to about 25 years. This treatment would occur on 3,433 acres. Alt 3 would treat 172 acres with prescribed burn only and of this, canopy base heights would be increased where there is an overstory similar to Alt 2 – just over 25 feet on the average and probability of torching reduced to between 15-40%

Resource Element	Indicator/Measure	Alt 1	Alt 2	Alt 3
Crown Fuels	Canopy Bulk Density & Crowning Index (wind in mph)	Without treatment, dense timber stands retain current CBD levels. CBD in forested stands proposed for treatment range from approximately 10-25 kg/m3, levels in which active crown fire could occur with winds less <15 mph, under high fire danger conditions.	Following regeneration timber harvest, canopy bulk density would be reduced by as much as 80% to approximately <0.03 kg/m3. This makes fire spread as active crown unrealistic. In a simulation, it would take winds >60-80 mph for active crown burning to occur. Prescribed burn only treatments would reduce less of the overstory over the treatment area as compared to harvest, because the burns would result in a mosaic of fire effects. In a simulation, prescribed burning could result in canopy bulk density reduction of about ½ (from 0.18 kg/m3 to 0.08 kg/m3) and an increase of crowning index from about 13 mph up to 26 mph. These results would be variable as would the burns.	Following regeneration timber harvest, canopy bulk density would be reduced by as much as 80% to approximately <0.03 kg/m3. This makes fire spread as active crown unrealistic. In a simulation, it would take winds >60-80 mph for active crown burning to occur. Prescribed burn only treatments under Alternative 3 occur primarily in areas where canopy bulk density reduction is not the primary goal. About 1/3 of the 172 acres (in the vicinity of Boulder Meadows – Unit 12) have a dense timber overstory. In these areas prescribed burning could result in CBD reduction of about ½ (similar to Alt. 2) and increase the crowning index from about 13 mph up to 26 mph. These results could be quite variable depending on results of the burns.

Compliance with the Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

The action alternatives are consistent with some of the direction in the Forest Service Manual (FSM 5100), however, some of the direction does not apply due to the scope of the project. Alternatives 2 and 3 would alter fuel profiles (removal of danger trees) so that public and firefighter safety is improved and would achieve desired conditions and attain management objectives in the IPNF Forest Plan, including management of fuels adjacent to values at risk.

Forest Plan compliance occurs through the treatment of fuels in the WUI and adjacent to values-at-risk, as well as ensuring firefighter and public safety during fire management activities. In addition, the Forest Plan requires compliance with all applicable federal, state or tribal air quality standards.

Desired conditions, objectives and guidelines related to fire:

- FW-DC-FIRE-01: Public and firefighter safety is always recognized as the first priority for all fire management activities.
- FW-DC-FIRE-02: Hazardous fuels are reduced within the WUI and other areas where values are at risk.

- FW-DC-FIRE-03: The use of wildland fire (both planned and unplanned ignitions) increases in many areas across the forest. Fire plays and increased role in helping to trend the vegetation towards the desired conditions while serving other important ecosystem functions.
- FW-DC-SES-04: To the extent possible, the Forest contributes to the protection of communities and individuals from wildfire within the limits of firefighter safety and budgets.
- FW-OBJ-FIRE-01: The outcome is the treatment of fuels on approximately 6,000 to 16,000 acres annually on NFS lands. NFS lands within the WUI are the highest priority for fuels treatment.
- FW-OBJ-FIRE-02: Over the life of the Plan, manage natural, unplanned ignitions to meet resource objectives on at least 10 percent of ignitions.
- MA4a-GDL-FIRE-01: Planned ignitions or the use of natural, unplanned ignitions may only occur as identified in the RNA Establishment Record or approved RNA management plan.
- MA5-GDL-FIRE-01: Natural, unplanned ignitions, as well as planned ignitions, may be used to meet resource objectives.
- MA6-GDL-FIRE-01: Fuels are reduced, particularly within the WUI, to reduce the threat of wildland fire.
- GA-DC-FIRE-LK-01: Threats of wildfire are reduced for the following specific areas: communities of Bonners Ferry, Moyie Springs, Naples, Eastport, Porthill, Copeland, Moravia: the Kootenai Tribal community; outlying communities and structures, and Highway 2, Highway 95, and Highway 200 corridors.

Alternatives 2 and 3 are consistent with the IPNF Forest Plan desired conditions, objectives and guidelines related to fire. Both action alternatives would implement treatments to reduce fuels within the WUI. Taking action to reduce fuels in the vicinity of Black Mountain prioritizes firefighter safety, as these activities would provide treated areas from which ground crews could safely take action, within the limits of direct attack. Implementing treatment to protect the communication infrastructure and adjacent watersheds contributes to the protection of the communities of Boundary County.

For Alternative 2, the use of planned ignitions to trend towards desired vegetative conditions is consistent with the Forest Plan for both MA5 and MA6 – the majority of planned ignitions would occur in the Backcountry, which is the preferred mechanism for treating vegetation. Both action alternatives are consistent with the objective of managing 10 percent of natural ignitions for resource objectives in that activities will not necessarily prohibit this option in the future. However, because Alternative 2 would implement over 7,400 acres of prescribed fire to moderate fuels, it is possible these treatments could expand a line officer’s decision space in utilizing future fire to achieve resource objectives across the landscape in the future. This would not occur under Alternative 3. Harvest treatments followed by prescribed burning will reduce fuels in all layers and will help meet the overall goals of reducing fuels on approximately 6,000 to 16,000 acres annually.

Alternative 1 (no action) would be inconsistent with many of the above forest-wide and management area specific desired conditions, objectives and guidelines because it would not:

- reduce fuels, particularly within the WUI and where values are at risk
- treat fuels to help achieve annual treatment targets, or

- take steps to prioritize safety of firefighters and the public in the event of a wildfire

If no action were taken, the Forest Supervisor could still decide to manage natural, unplanned ignitions for resource benefits across much of this area. In addition, with no action taken, all future fires would still be managed with the priority of firefighter and public safety.

Forest-wide desired condition and guideline related to Air Quality:

- FW-DC-AQ-01: The Forest meets applicable federal, state, or tribal air quality standards. Prescribed burning is planned to meet those standards, including areas classified as Class 1 airsheds (e.g., Cabinet Mountains Wilderness) and nonattainment areas.
- FW-GDL-AQ-01: The Forest should cooperate with the federal, state, tribal, and local air quality agencies as appropriate in meeting applicable air quality requirements.

The IPNF complies with the recommendations provided by air quality regulating agencies in regards to activities related to fire and fuels management, such as prescribed burning. Any burning that takes place in relation to Alternatives 2 and 3 will be consistent with this guideline.

Lastly, the action alternatives are consistent with the FLAME Act, Federal Fire Policy (1995, updated 2001 and Guidance for the Implementation for Federal Wildland Fire Management Policy, 2009), as well as Forest Service Manual 5100. Any prescribed burning that would take place would be to meet the desired conditions in the Forest Plan, to protect values at risk, and would be implemented with the number one priority of ensuring firefighter and public safety. In addition, fuel profiles would be altered, such that safety is improved and fuels would be treated as necessary adjacent to values-at-risk so they are less vulnerable to the impacts of future wildfires.

Glossary

All of the following definitions can be found in the Glossary of Wildland Fire Terminology.

Fire:

- Hazard: A fuel complex, defined by volume, type condition, arrangement, and location, that determines the degree of ease of ignition and of resistance to control.
- Intensity: The heat released at the flaming front of a fire (can be numerically represented as the heat released per unit of time for each unit length of fire edge).
- Potential: The likelihood of a wildland fire event measured in terms of anticipated occurrence of fire(s) and management's capability to respond. Fire potential is influenced by a sum of factors that includes fuel conditions (fuel dryness and/or other inputs), ignition triggers, significant weather triggers, and resource capability.
- Risk: The chance of fire starting, as determined by the presence and activity of causative agents.
- Severity: Degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and residence time.

Flame height: The average maximum vertical extension of flames at the leading edge of the fire front.

Flame length: The distance between the flame tip and the midpoint of the flame depth at the base of the flame (generally the ground surface), an indicator of fire intensity.

Fuel: Any combustible material.

Wildland Urban Interface: The line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels.

References Cited

Abella, S.R., W.W. Covington, P.Z. Fule, L.B. Lentile, A.J. Sanchez Meador, and P. Morgan. 2007. Past, present, and future old growth in frequent-fire conifer forests of the western United States. Ecology and Society. 12(2): 16

A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment: 10-year Comprehensive Strategy Implementation Plan. May 2002. http://www.fireplan.gov/reports/11-23-en.pdf

Agee, J.K. 1999. Effects on Landscape Fragmentation in Interior West Forests. p. 43. In: Rochelle, J.A., Lehmann., L., and J. Wisniewski. 1999. Forest Fragmentation: Wildlife and Management Implications. 322 pages.

Agee, James K. 2002. The fallacy of passive management. Conservation Biology in Practice. 3(1): 18-25.

Agee, James K., Bahro, Berni., Finney, Mark A., Omi, Philip N., Sapsis, David B., Skinner, Carl N., van Wagtendonk, Jan W., Weatherspoon, C Phillip. 2000. The use of shaded fuelbreaks in landscape fire management. Forest Ecology and Management. 127: 55-66

Agee, James K., and Skinner, Carl N. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management. 211: 83–96.

Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. Gen. Tech. Rep. INT-GTR-122. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 22 p.

Arno, Stephen F., Parsons, David J., and Robert E. Keane. 2000. Mixed-severity fire regimes in the Northern Rocky Mountains: Consequences of fire exclusion and options for the future. USDA Forest Service Proceedings. RMRS-P-15-Vol-5. Ogden, UT.

Baker, W.L., T.T. Veblen, R.L. Sherriff. 2006. Fire, fuels and restoration of ponderosa pine-Douglas-fir forest in the Rocky Mountains, USA. Journal of Biogeography.

Binkley, D., T. Sisk, C. Chambers, J. Springer, and W. Block. 2007. The role of old-growth forests in frequent-fire landscapes. Ecology and Society. 12(2): 18

Boundary County, Idaho Wildland/Urban Interface Fire Mitigation Plan. 2003.

Brackebusch, Arthur P. 1973. Fuel Management – A prerequisite, not an alternative to fire control. Journal of Forestry. 71:637-639.

Brown, James K. 1974. Handbook for inventorying downed woody material. USDA Forest Service Gen. Tech. Rep. INT-16. Intermountain Forest and Range Experiment Station. Ogden, UT.

Brown, James K., Reinhardt, Elizabeth D., Kramer, Kylie A. 2003. Coarse woody debris: Managing benefits and fire hazard in the recovering forest. Gen. Tech. Rep. RMRS-GTR-105. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 16 p.

Butler, B.W., Anderson, W.R., and E.A. Catchpole. 2007. Influence of slope on fire spread rate. In: Butler, Bret W.; Cook, Wayne, comps. The fire environment--innovations, management, and policy; conference proceedings. 26-30 March 2007; Destin, FL. Proceedings RMRS-P-46CD. Fort

Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. CD-ROM. p. 75-82

Cohen, J.D., and Butler, B.W. 1998. Modeling potential structure ignitions from flame radiation exposure with implications for wildland/urban interface fire management. 13th Fire and Forest Meteorology Conference, Lorne, Australia 1996. International Association of Wildland Fire.

Cooper, S.V., Nieman, K.E., Steele, R., Roberts, D.W. 1991. Forest Habitats of northern Idaho: a second approximation. Gen. Tech. Rep. INT-236. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 135 p.

Finney, M.A., 2001. Design of regular landscape fuel treatment patterns for modifying fire growth and behavior. Forest Science. 47(2): 219–228.

Finney, Mark A., McHugh Charles W., and Grenfell, Isaac C., 2005. Stand- and landscape-level effects of prescribed burning on two Arizona wildfires. Canadian Journal of Forest Research. 35: 1714-1722.

Finney, Mark A., Seli, Rob C., McHugh Charles W., Ager, Alan A., Bahro, Bernard, and Agee James K., 2007. Simulation of long-term landscape-level fuel treatment effects on large wildfire. International Journal of Wildland Fire. 16: 712-727.

Graham, Russell T.; Harvey, Alan E.; Jurgensen, Martin F.; Jain, Theresa B.; Tonn, Jonalea R.; Page-Dumroese, Deborah S. 1994. Managing coarse woody debris in forests of the Rocky Mountains. Res. Pap. INT-RP-477. Ogden, UT: U.S. Department of Agriculture, Forest Service, lntermountain Research Station. 12 p.

Graham, Russell T., Harvey, Alan E., Jain, Theresa B., Tonn, Jonalea R. 1999. The effects of thinning and similar stand treatments on fire behavior in western forests. Gen. Tech. Rep. PNW-GTR-463. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 27 p.

Graham, Russell T.; McCaffrey, Sarah; and Theresa B. Jane, tech. eds. 2004. Scientific basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 43 p. http://www.fs.fed.us/rm/main/fire_plan/index.html

Hessburg, Paul F., Agee, James K., Franklin, Jerry F. 2005 Dry forests and wildland fires of the inland Northwest USA: Contrasting the landscape ecology of the pre-settlement and modern eras. Forest Ecology and Management. 211: 117-139.

Keane, Robert E.; Dickinson, Laura J. 2007. The photoload sampling technique: estimating surface fuel loadings from downward-looking photographs of synthetic fuelbeds. General Technical Report RMRS-GTR-190. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 44 p.

Keane, R.E., Reinhardt, E.D., Scott, J., Gray, K., Reardon, J. 2005. Estimating forest canopy bulk density using six indirect methods. Canadian Journal of Forest Research. 35: 724-739.

Lotan, J., Brown, J. and Neuenschwander, L. (1985). Role of fire in lodgepole pine forests, pp. 133-152 in D. Baumgartner et al. (eds) Lodgepole pine the species and its management Symposium Proceedings. Washington State University, Pullman.

Martinson, Erik J.; Omi, Philip N. 2013. Fuel treatments and fire severity: A meta-analysis. Research Paper. RMRS-RP-103WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 38 p.

McKenzie, D., Gedalof, Z,, Peterson, D,L., and P. Mote. 2004. Climatic change, wildfire, and conservation. Conservation Biology. Volume 18, No. 4: 890-902

National Fire Plan, 2000. https://www.forestsandrangelands.gov/resources/overview/

National Wildfire Coordination Group 2006. Fireline Handbook. NWCG Handbook 3. PMS 410-1. pp 1-437. http://www.nwcg.gov/pms/pubs/410-1/410-1.pdf

Peterson, David W., Dodson, Erich K., Harrod, Richy J., 2015. Post-fire logging reduces surface woody fuels up to four decades following wildfire. Forest Ecology and Management. Volume 338. Pages 84-91.

Pfister, Robert D. Daubenmire, R. 1975. Ecology of lodgepole pine. In: Smith, J.K, and W.C. Fischer. 1997. Fire Ecology of Forest Habitat Types of Northern Idaho. General Technical Report. INT-GTR-363. Ogden, UT: USDA, Forest Service, Intermountain Research Station.

Pollet, Jolie, and Omi, Philip M. 2002. Effect of thinning and prescribed burning on crown fire severity in ponderosa pine forests. International Journal of Wildland Fire. 11: 1-10.

Prichard, S.J. and M.C. Kennedy. 2014. Fuel treatments and landform modify landscape patterns of burn severity in an extreme fire event. Ecological Applications. 24(3): 571-590

Prichard, S.J., Peterson, D.L., and K. Jacobson. 2010. Fuel treatments reduce the severity of wildfire effects in dry mixed conifer forest, Washington, USA. Canadian Journal of Forest Research. 40: 1615-1626.

Rebain, Stephanie A. comp. 2010 (revised March 23, 2015). The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 403p.

Reinhardt, Elizabeth D., Keane, Robert E., Calkin, David E., and Jack D. Cohen. 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. Forest Ecology and Management. 256: 1997-2006.

Rothermel, R.C., 1972. A mathematical model for predicting fire spread in wildland fuels, General Technical Report INT-115, Ogden, UT; U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station

Rothermel, R.C., 1983. How to predict the spread and intensity of forest and range fires. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-143, 161 pp.

Schoennagel, Tania., Veblen, Thomas T., and Romme, William H. 2004. The interaction of fire, fuels and climate across Rocky Mountain forests. BioScience. 54:7; 661-676

Scott, Joe H.; Burgan, Robert E. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p.

Scott, Joe H.; Reinhardt, Elizabeth D. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Res. Pap. RMRS-RP-29. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 59 p.

Scott, Joe H.; Reinhardt, Elizabeth D. 2005. Stereo photo guide for estimating canopy fuel characteristics in conifer stands. Gen. Tech. Rep. RMRS-GTR-145. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49 p.

Smith, J.K., and W.C. Fischer. 1997. Fire ecology of the forest habitat types of northern Idaho. Gen. Tech. Rep. INT-GTR-363. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 142 p.

Spurr, S.H., Barnes, B.V. 1980. Forest ecology. New York: John Wiley. 687 p.

Stephens, S.L, Moghaddas, J. J., Edminster, C., Fieder C.E., Haase, S., Harrington, M., Keeley, J.E., Knapp, E.E., McIver, J.D., Metlen, K., Skinner, C.N., and A. Youngblood. 2009. Fire treatment effects on vegetation structure, fuels and potential fire severity in western U.S. forests. Ecological Applications. 19(2): 305-320

USDA Forest Service. Forest Service Manual, Title 5100 Fire Management USDA Forest Service. Washington D.C.

USDI and USDA 2009. Guidance for the Implementation of Federal Wildland Fire Management Policy.

Vaillant, N.M., Fites-Kaufman, J.A., S.L. Stephens. 2006. Effectiveness of prescribed fire as a fuel treatment in California coniferous forests. USDA Forest Service Proceedings RMRS-P-41. Pages 465-476.

Van Wagner, C.E. (1977) Conditions for the start and spread of crown fire. Canadian Journal of Forest Research. 7: 23-34.

Van Wagtendonk, J.W., 1996. Use of deterministic fire growth model to test fuel treatments. In: Sierra Nevada Ecosystem Project: Final Report to Congress, vol. II. Assessments and Scientific Basis for Management Options. University of California, Davis. Centers for Water and Wildlife Resources, 1155-1165

Weatherspoon, C.P., Skinner C.N., 1996. Landscape-level strategies for forest fuel management. In: Sierra Nevada Ecosystem Project: Final Report to Congress, vol. II. Assessments and Scientific Basis for Management Options. University of California, Davis. Centers for Water and Wildlife Resources, pp. 1471-1492.

Weise, D.R., and G.S. Biging. 1996. Effects of wind velocity and slope on flame properties. Canadian Journal of Forest Research. Volume 26: 1849-1858.

Weise, D.R., and G.S. Biging, 1997. A qualitative comparison of fire spread models incorporating wind and slope effects. Forest Science. 43(2): 170-180

Westerling, A.L, Hidalgo, H.G., Cayan, D.R., and T.W. Swetnam. 2006. Warming and early spring increases western U.S. forest wildfire activity. Science Express. Pages 940-943

Whitlock, Cathy, Shafer, Sarah L., Marlon, Jennifer. 2003. The role of climate and vegetation change in shaping past and future fire regimes in the northwestern US and implications for ecosystem management. Forest Ecology and Management. 178: 5-21.

Zack, A. C., and P. Morgan. 1994. Fire history on the Idaho Panhandle National Forest. Unpublished report on file at USDA Forest Service, Idaho Panhandle National Forest, Coeur d'Alene, Idaho, USA.